

# EDN<sup>®</sup>

Micropower op-amp  
applications

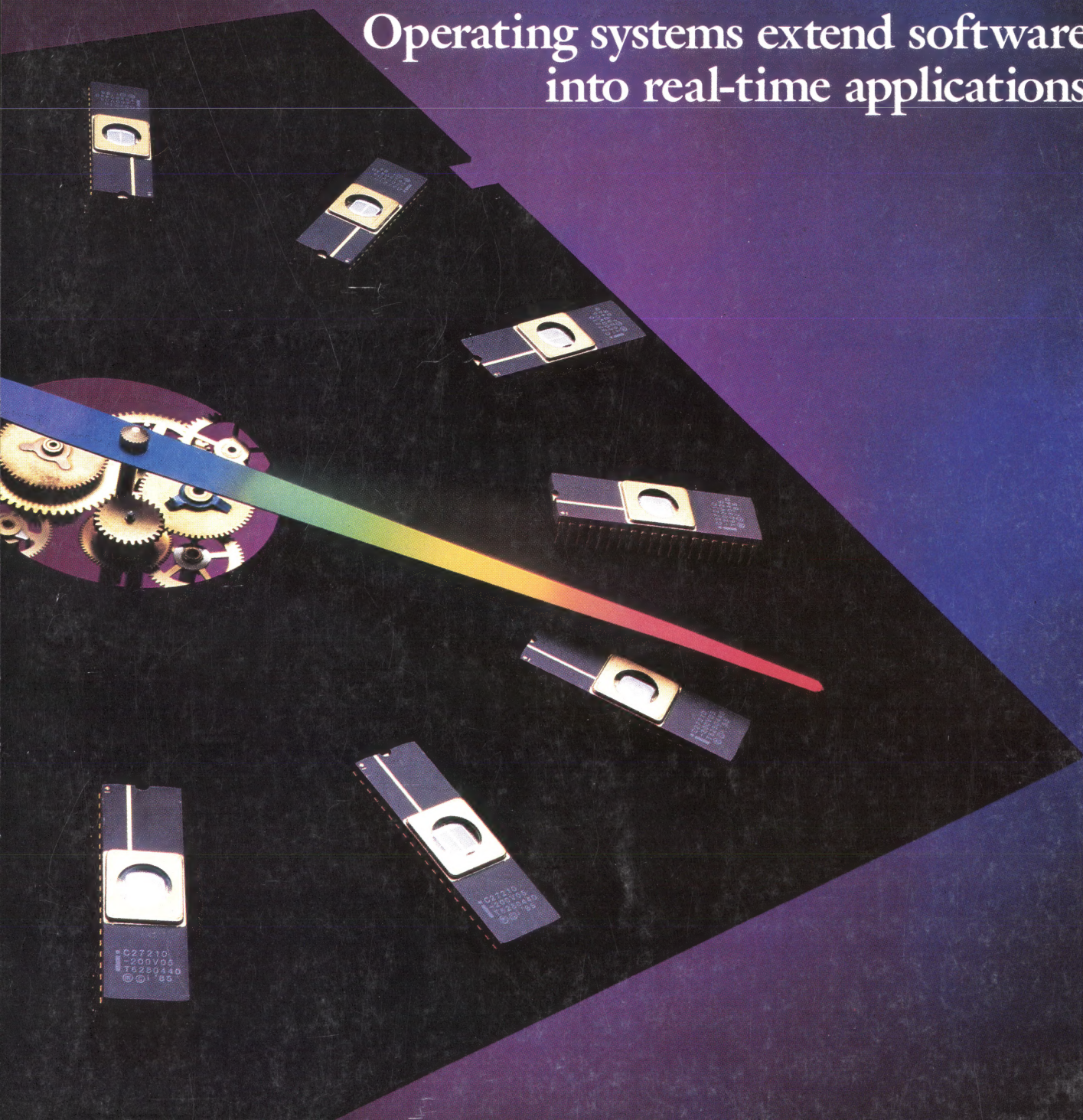
DC/DC converters  
for low-power circuits

1988 calendar of  
industry events

Telephone ICs

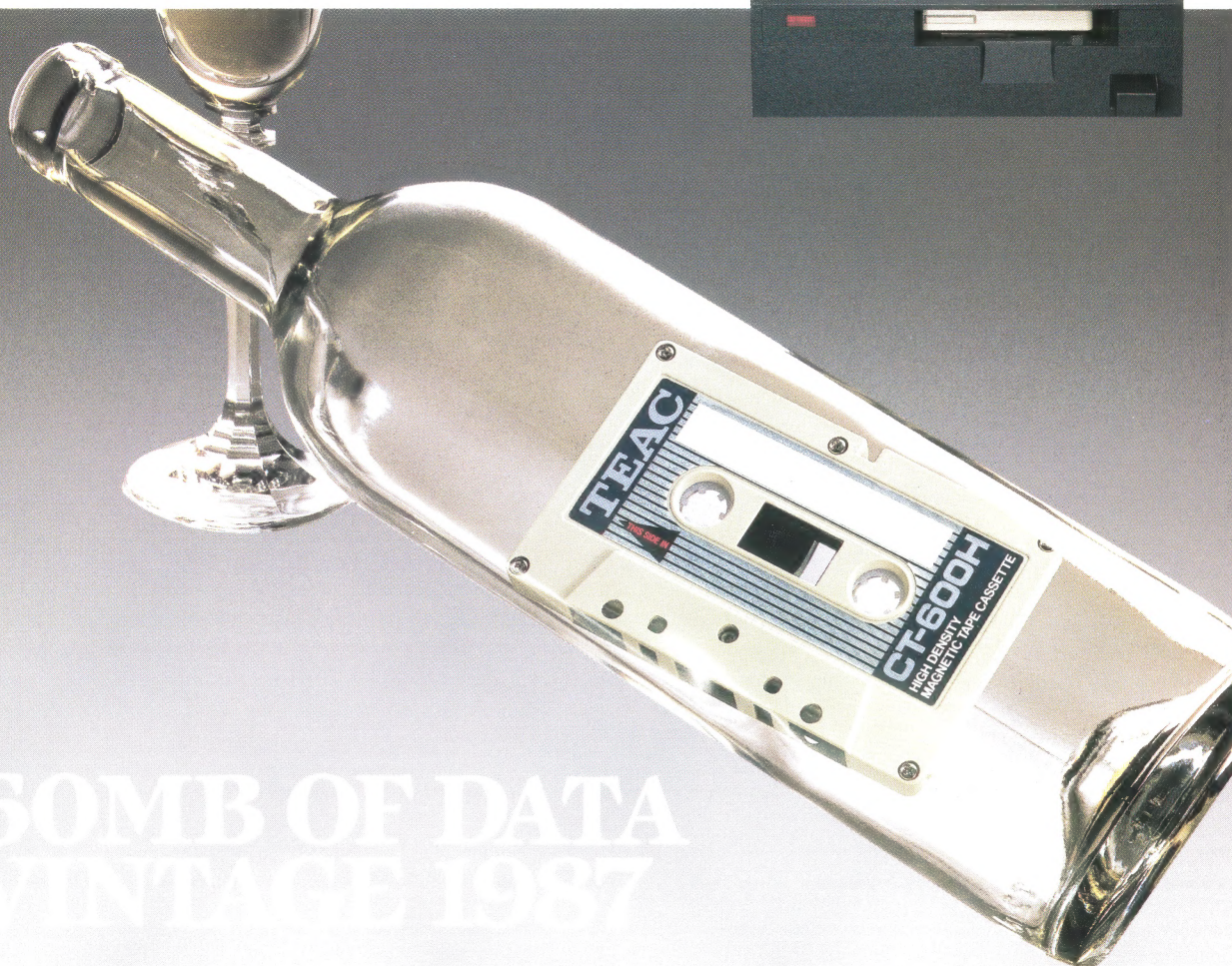
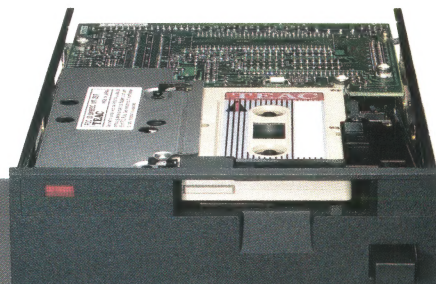
ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

Operating systems extend software  
into real-time applications



# MT-2ST

## HALF-HEIGHT DIGITAL CASSETTE DATA STREAMERS: AN IDEA WHOSE TIME HAS COME



# 60MB OF DATA VINTAGE 1987

### FAST, SIMPLE AND RELIABLE BACKUP WITH INTERCHANGEABLE MEDIA

Every year is a "vintage" when it comes to hard disk backup. No one can afford to have 60MB of data go sour. Use the TEAC MT-2ST data streamer for day-to-day backup or archival storage. Data cassettes are rugged, compact, ultrareliable, and cost-competitive. Direct reel drive enables precise speed/positional control without time-consuming media preformatting. Store anything from a single file to entire disk image under DMA control. And do it in 4 minutes (20MB), 10 (50MB) or 12 (60MB).

Full media compatibility means that complete data bases can be sent through the mail. D/CAS-05 (QIC-02), SCSI, or D/CAS-15 (QIC-36) interfaces available. Built-in data formatter for excellent space factor.

# TEAC<sup>®</sup>

## For Memories You'll Be Glad To Have

TEAC CORPORATION:

3-7-3 NAKA-CHO, MUSASHINO, TOKYO, JAPAN  
TEL: (0422) 53-1111 TLX: 2822451 FAX: (0422) 55-2554

■ Hong Kong, Nissei Sangyo Co. Ltd. Hong Kong Branch tel: 3-343441-6; KARIN ELECTRONIC SUPPLIES CO., LTD. tel: 3-898252 ■ Singapore, Nissei Sangyo Pte. Ltd. tel: 65-7372011; UAC CORPORATION tel: 7450082 ■ New Zealand, Northrop Instruments & Systems Ltd tel: 856-658 ■ Australia, Electrical Equipment Limited tel: 888-9000 ■ Indonesia, CHUGAI BOYEKI CO. LTD. tel: 370824 ■ Philippines, COMPEX INTERNATIONAL INC. tel: 213020 ■ India, Priya Electronics & Chemicals Limited tel: 2863611 ■ Kuwait, Bader Al Mulla & Brothers Co. W.L.L. tel: 2423250 ■ South Africa, EPSIDON TECHNOLOGY (PTY) LTD. tel: (011) 787-1030/33 ■ United Kingdom, TEKDATA LIMITED tel: 0782 813631 ■ F.R. Germany, nbn Elektronik GmbH tel: 08152/390 ■ Austria, nbn Elektronik GmbH tel: 04762/5444 ■ Netherlands, SIMAC ELECTRONICS B.V. tel: 040-582911 ■ Belgium and Luxemburg, SIMAC ELECTRONICS SPRL/PVBA tel: 02-219.24.53 ■ France, TEKELEC AIRTRONIC S.A. tel: (1) 4534-75-35 ■ Italy, A.E.S.S.E. S.p.A tel: 02-54.64.741-2-3 ■ Spain, ATALO Instrumentos S.A. tel: 733 05 62 ■ Switzerland, WENGER PERIPHERALS AG tel: 01/830 75 55 ■ Denmark, Dansk Binaer Teknik A/S tel: 03-662020 ■ Sweden, MACROTEK AB tel: 08-733 02 20 ■ Norway, SCANTELE AS tel: (2) 65 69 20 ■ Finland, INSTRUMENTARIUM ELEKTRONIIKKA tel: 0-5284350

\* If no distributor is listed above in your area, please contact us directly for further details about our products.

# Pick & Place.

**DALE**®

## Dale® Surface Mounted Components—for more choice in less space.

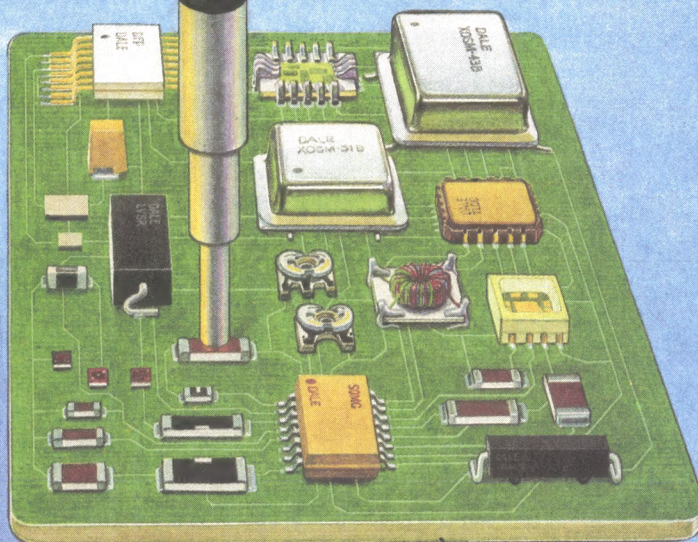
Pick Dale and place your surface mounted requirements in the hands of an industry leader. Dale's experience with surface mount technology began in 1970, when we introduced our first chip resistors. Today, Dale has a wide selection of basic surface mounted components to choose from. This choice offers you maximum flexibility in coordinating packaging and performance requirements.

You'll find the components at right already in use by major companies nationwide. These components are designed for automatic placement...compatible with standard soldering methods...and will help you shrink cost and board space.

Dale's unique blend of experience, selection and excellent service provides you with what you need to accelerate your surface mount progress. The numbers to call are: **Thick Film Resistor Networks**, **Thermistors**: El Paso, TX: 915-592-3253; **Thin Film Networks**, **Thick and Thin Film Chips**: Norfolk, NE: 402-371-0080; **Wirewound Resistors**: Columbus, NE: 402-564-3131; **Trimmer Potentiometers**, **Oscillators**: Tempe, AZ: 602-967-7874; **Inductors**, **Transformers**: Yankton, SD: 605-665-9301.

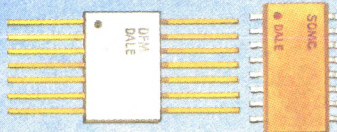
*Dale makes your basics better.*

CIRCLE NO 1



### Thick Film Networks

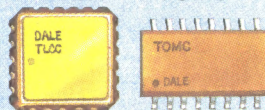
SOMC DFM DFP LCCC



Small outline molded dip package, ceramic chip carrier styles and flat pack (MIL-R-83401). All standard schematics. R/C styles available.

### Thin Film Networks

TLCC \*TOMC



Chip carrier styles and small outline molded dip package. All standard schematics.

### Thick Film Chips

CRCW RCWP RCWPM



Commercial and MIL-R-55342 styles. 1%, 2% & 5% tolerance. Standard sizes available from stock.

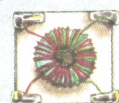
### Thin Film Chips

TNP \*TNPW

Commercial styles. Flow solderable. Single element and tapped, wire bondable.

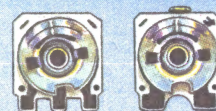
### Transformers

Custom designs available.



### Chip Potentiometers

ST



Standard, automatic or reverse adjustment. 100 ohms to 1 Meg.

### Thermistors

W H



NTC style. 5% & 10%,  $R_{25}$  tolerance.

### Chip Inductors

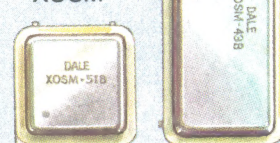
\*IMC



Molded style, 1  $\mu$ H to 1000  $\mu$ H. 10% & 20% tolerance.

### Oscillators

XOSM



Metal packages in two styles (XOSM-43, XOSM-51\*). Compatible with most logics. 240 Hz to 60 MHz.

### Wirewound Resistors

LVSR

\*WSM

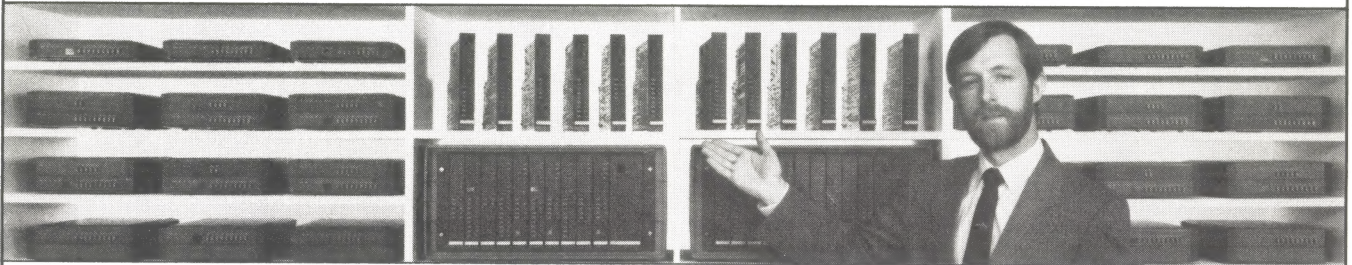


1, 2, 3, 5 watts including low value current sensing styles. "S" and Gull Wing leads.

\*Available soon.

**“We brought 19 products into full compliance.  
FCC, DOC, UL and CSA. 50 approvals!  
On time and on budget.**

***...Thanks, DS&G!”*** *Gavin Steven,  
British Telecom/  
Mitel Datacom*



## **BRITISH TELECOM CHOSE DS&G**

“A single compliance problem could have crippled our introduction and damaged our reputation. We chose the best R&D facility to help us.”

## **“WE KNEW ENOUGH NOT TO GO IT ALONE”**

Until 1984, British Telecom was itself the telecommunications approval authority in Great Britain. They understand the benefits of using an independent laboratory solely dedicated to compliance approvals and totally familiar with the smallest regulatory details.

## **“WE CHOSE THE BEST U.S. R&D FACILITY”**

Dash Straus & Goodhue is much more than the East Coast's largest R&D facility specializing in compliance. It actively consults with the U.S. government on compliance matters, runs the industry's most extensive seminar and training programs, publishes the industry's sourcebook, Compliance Engineering, and handles world-wide compliance programs.

## **BEYOND TESTING TO TOTAL SOLUTIONS**

DS&G can handle every aspect of your compliance program, including all paperwork and liaison with government agencies. DS&G offers initial design assistance, full product safety, emissions and telecom testing, and complete retrofit designs.

## **LESS WORRY, LESS DELAY, LOWER COST**

Estimated completion dates and prices are given up front. Because DS&G engineers and lawyers are compliance experts, most clients find costs to be far less, and the company's compliance position safer, than with internally run programs.

TO LEARN MORE, CALL OR WRITE: 617-263-2662

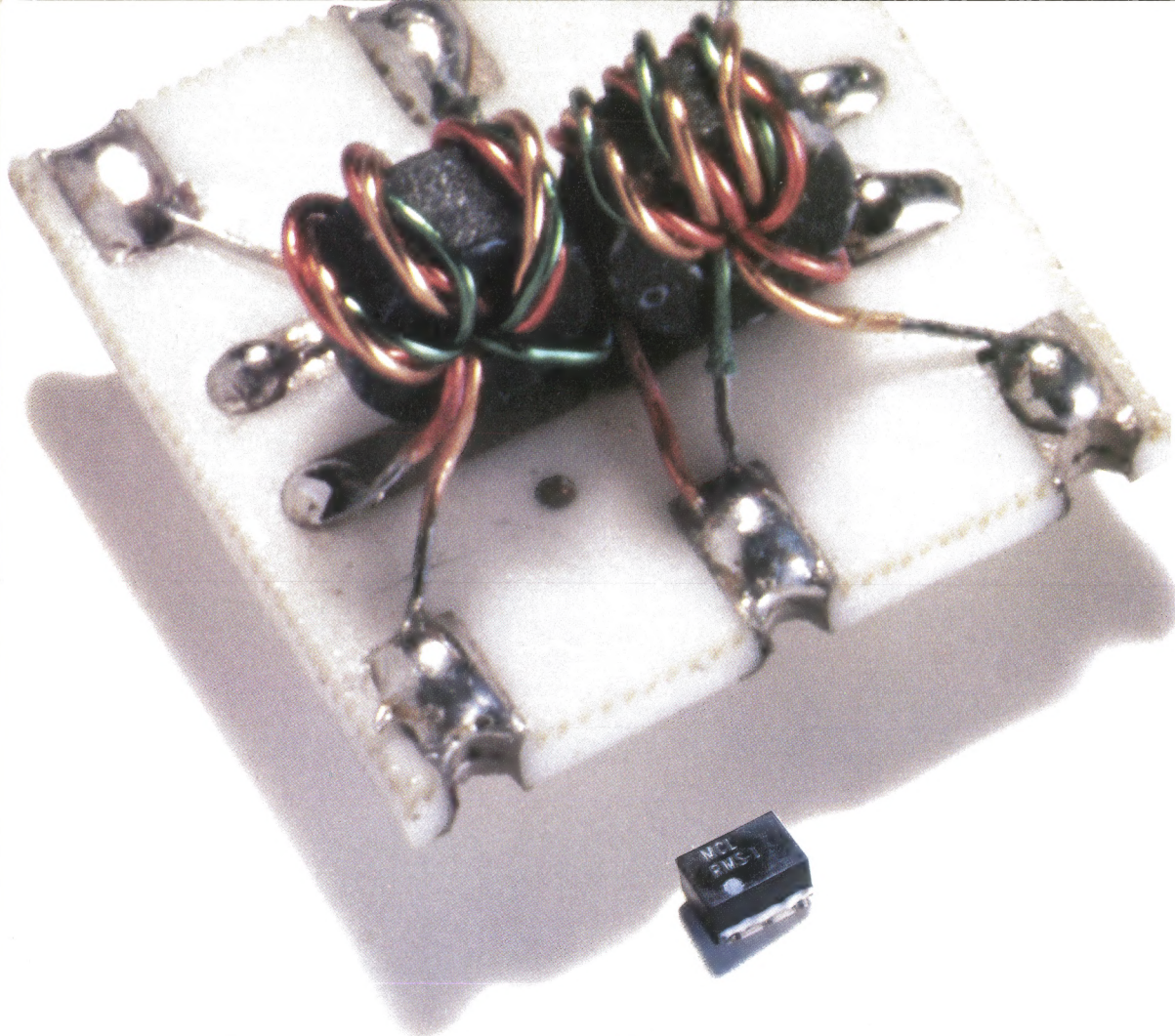
**DS&G**  
Dash Straus & Goodhue

Dash Straus & Goodhue, Inc.  
593 Massachusetts Avenue, Boxborough, MA 01719  
Telex: 317-632 DASH



NVLAP

Accredited by the National Bureau of Standards for Emissions and Telecommunications Testing



# the world's smallest surface mount mixers **\$6<sup>95</sup>** from

Tight packing density, lowered assembly costs, and improved reliability make surface-mount technology (SMT) highly attractive to systems and product manufacturers. If your design is ready for SMT, specify Mini Circuits' new RMS series, the world's smallest (0.25 by 0.30 by 0.2 in.) double-balanced SMT mixers, spanning 0.5 to 1000MHz, from only \$6.95 (10-49 qty).

The tiny, non-hermetic package houses RF transformers, a ceramic-alumina substrate, and a four-diode assembly. A unique edge-plated design eases the job of making reliable solder connections to a printed-circuit board. A protective-barrier layer on top of the package's conductive layer retards the harmful effect of electromigration which may occur during soldering. The RMS can be attached to a pc-board by conventional manual soldering or with automatic equipment; mixers can be supplied in a tape-and-reel format for automated pick-and-place machines.

When you think SMT, think small, low-cost...  
think Mini-Circuits RMS series.

finding new ways...  
setting higher standards

## Mini-Circuits

A Division of Scientific Components Corporation  
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500  
Domestic and International Telexes: 6852844 or 620156

### SPECIFICATIONS

#### FREQUENCY RANGE, MHz

LO, RF

IF

#### CONVERSION LOSS, dB, Typ.

Mid-band ( $10f_l - f_{u/2}$ )

Total range ( $f_l - f_u$ )

#### ISOLATION, dB, Typ.

Low-band ( $f_l - 10f_l$ )

Mid-band ( $10f_l - f_{u/2}$ )

Upper-band ( $f_{u/2} - f_u$ )

#### PRICE (10-49)

#### RMS-1

0.5 — 500

DC — 500

5.5

6.2

L-R

55

33

27

**\$6.95**

#### RMS-2

5 — 1000

DC — 500

6.5

7.0

L-R

55

35

25

**\$7.95**

$f_l$  = lowest frequency in range

$f_u$  = highest frequency in range

F110 REV. ORIG.

# tiny SPDT switch

**dc to 4.6GHz... \$32<sup>95</sup>** (1-24)



Tough enough to pass stringent MIL-STD-202 tests, useable from dc to 6GHz operation, and smaller than most RF switches, Mini-Circuits' hermetically-sealed KSW-2-46 offers a new, unexplored horizon of applications.

Unlike pin diode switches that become ineffective below 1MHz, this GaAs switch can operate down to dc with control voltage as low as -5V, at a blinding 2ns switching speed.

Despite its extremely tiny size, only 0.185 by 0.185 by 0.06 in., the KSW-2-46 provides 50dB isolation (considerably higher than many larger units) and insertion loss of only 1dB. The surface-mount unit can be soldered to pc boards using conventional assembly techniques. The KSW-2-46, priced at only \$32.95, is yet another example of components from Mini-Circuits with unbeatable price/performance.

**Switch fast...to Mini-Circuits' KSW-2-46**

## SPECIFICATIONS

FREQ. RANGE	dc-4.6 GHz	
INSERT. LOSS (db)	typ	max
dc-200MHz	0.9	1.1
200-1000MHz	1.0	1.3
1-4.6GHz	1.3	1.7
ISOLATION (dB)	typ	min
dc-200MHz	60	50
200-1000MHz	45	40
1-4.6GHz	30	23
VSWR (typ)	1.3:1	
SW. SPEED (nsec)		
rise or fall time	2(typ)	
MAX RF INPUT (dBm)		
up to 500MHz	+17	
above 500MHz	+27	
CONTROL VOLT.	-5V on, OV off	
OPER/STOR TEMP.	-50 to +100°C	
PRICE	\$32.95 (1-24)	

finding new ways ...  
setting higher standards

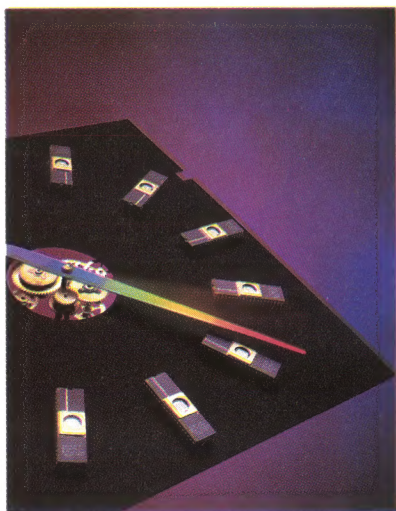
**Mini-Circuits**

A Division of Scientific Components Corporation  
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500  
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156

CIRCLE NO 140

C 117 REV. A

EDN January 7, 1988



*On the cover: Real-time operating systems are introducing order into chaos. See pg 114. (Photo courtesy Intel Corp)*

## DESIGN FEATURES

### Special Report: Real-time operating systems

114



A real-time operating system can enable you to design and write a large real-time software system as a collection of simple, potentially reusable routines. But using a formal real-time OS means learning a completely new programming style.—*Charles H Small, Associate Editor*

### DC/DC converters adapt to the needs of low-power circuits

145

High cost, quiescent current, and circuit complexity have often restricted switching power supplies to high-power applications, for which the switchers' high efficiency, wide input range, and reduced size and weight offset their drawbacks. Now, however, you can advantageously employ switchers in low- and medium-power applications.—*Len Sherman, Maxim Integrated Products*

### Proper glitch capture requires knowledge of logic-analyzer limits

157

Using a logic analyzer to locate the source of intermittent malfunctions in digital systems can prove to be extremely frustrating. If you understand your analyzer's capabilities and limitations, though, you raise the odds of having the instrument furnish the information you need.—*Wolfgang Schweitzer, Kontron Messtechnik*

### Integrated PLDs support Multibus II bus arbitration

165

The incorporation of buried state registers in PLDs makes the devices suitable for the design of sequential machines. Such devices thus provide compact packages for containing the bus-arbitration logic in Multibus II systems.—*Arthur Khu, Advanced Micro Devices*

### Micropower op amp offers simplicity and versatility

181

An op amp whose input range includes both supply rails and whose output voltage swings within 100 mV of those rails can simplify a circuit by eliminating certain traditional components.—*Zahid Rahim, Signetics Corp*

*Continued on page 7*



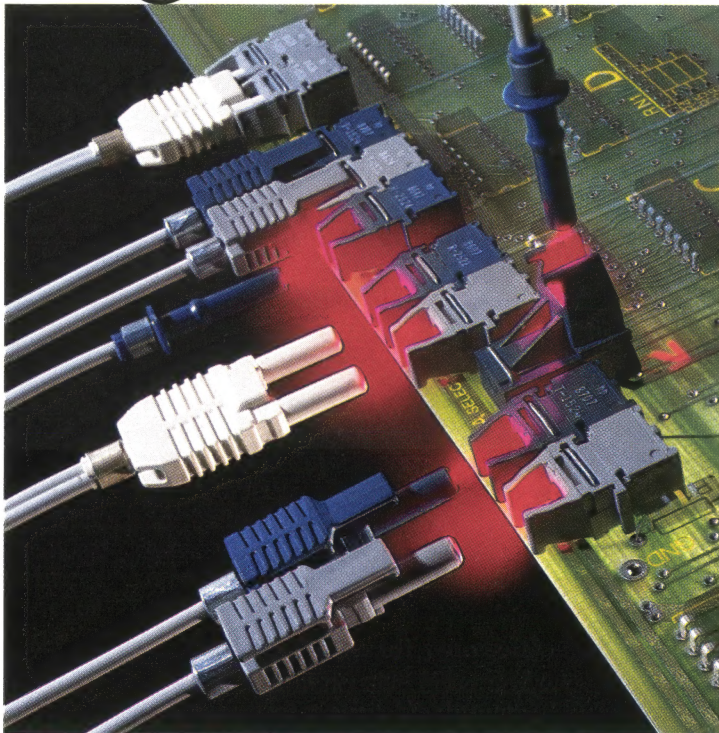
**BPA ABP**



EDN® (ISSN 0012-7515) is published 38 times a year (biweekly with 1 additional issue a month) by Cahners Publishing Company, A Division of Reed Publishing USA, 275 Washington Street, Newton, MA 02158-1630. Terrence M McDermott, President; Frank Sibley, Electronics/Computer Group Vice President; Jerry D Neth, Vice President/Publishing Operations; J J Walsh, Financial Vice President/Magazine Division; Thomas J Dellamaria, Vice President/Production and Manufacturing. Circulation records are maintained at Cahners Publishing Company, 44 Cook Street, Denver, CO 80206-5191. Telephone: (303) 388-4511. Second-class postage paid at Denver, CO 80206-5191 and additional mailing offices. POSTMASTER: Send address corrections to EDN® at the Denver address. EDN® copyright 1988 by Reed Publishing USA; Saul Goldweitz, Chairman; Ronald G Segel, President and Chief Executive Officer; Robert L Krakoff, Executive Vice President; William M Platt, Senior Vice President. Annual subscription rates for nonqualified people: USA, \$95/year; Canada/Mexico, \$110/year; Europe air mail, \$135/year; all other nations, \$135/year for surface mail and \$200/year for air mail. Except for special issues where price changes are indicated, single copies of regular issues are available for \$6, \$8, and \$10 (USA, Canada/Mexico, and foreign). Please address all subscription mail to Eric Schmierer, 44 Cook Street, Denver, CO 80206-5191.

# SURPRISE!

The old limits are off...  
fiber optic  
design constraints.



Meet Hewlett-Packard's *Versatile Link* HFBR-0501 series of fiber optic components. Innovative HP technology now makes the noise and interference immunity of fiber optics accessible and easy to use for short-distance applications. This opens up significant new voltage isolation and data communication design possibilities in pc board intercommunications, instruments, computers and test equipment.

HP's *Versatile Link* is TTL- and CMOS-compatible. Data rates can go from DC to 5 megabits/sec. Low profile mounts allow tight board stacking. Three styles of connectors, including

latching and duplex, permit almost any configuration called for by your design.

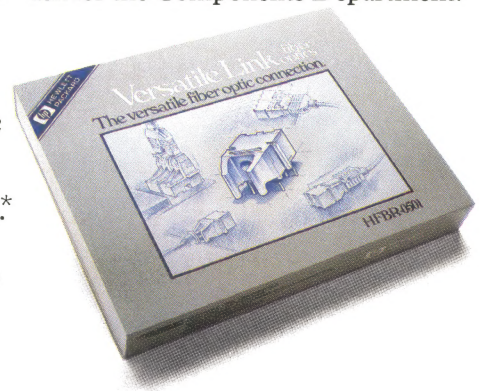
Plus, it can be auto-inserted and wave-soldered. And, no optical design is required...making it remarkably cost-effective.

#### Take the limits off yourself!

A comprehensive *Versatile Link* evaluation kit is available through your authorized Hewlett-Packard components distributor for just \$24.95\* (Order Part No. HFBR-0501.) In the U.S., contact: Almac Electronics, Hall-Mark, Hamilton/Avnet, or Schweber. In Canada: Hamilton/Avnet or Zentronics Ltd.

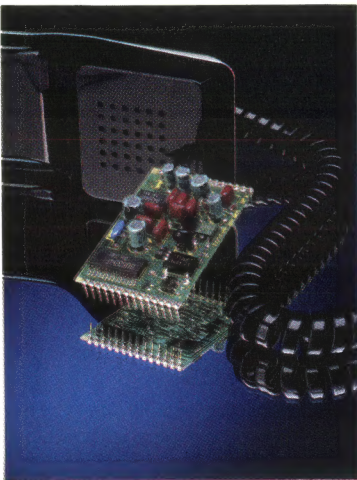
\*U.S. List price.

For more information, call the Hewlett-Packard sales office listed in your telephone directory white pages and ask for the Components Department.



**HEWLETT  
PACKARD**

CIRCLE NO 137



Just-introduced telecomm ICs offer economical ways to upgrade telephone- and PABX-system designs (pg 55).

EDN magazine now offers Express Request, a convenient way to retrieve product information by phone. See the Reader Service Card in the front for details on how to use this free service.



## TECHNOLOGY UPDATE

### Telecomm ICs offer improved functions for telephone- and PABX-system designs 55

The latest offerings from telecomm-IC manufacturers not only continue the general trend toward higher integration by incorporating more functions than previous telecomm ICs did—they also substantially improve on those functions.—*Dave Pryce, Associate Editor*

### Analog comparators achieve high speeds, but application challenges remain 75

High-speed analog comparators have always presented design challenges, and the state-of-the-art devices discussed in this article are no exception.—*David Shear, Regional Editor*

### Raster printers profit from available technologies to suit diverse uses 87

Almost all computer applications today rely on hard-copy-output devices, and with the abundance of raster-printing technologies available, you can now match a raster printer with just about any application.—*Maury Wright, Regional Editor*

## PRODUCT UPDATE

500-kHz to 1-GHz hybrid amplifier	103
Frequency- and time-measuring analyzer	104
Scientific calculators	106

## DESIGN IDEAS

Baseline restorer is voltage programmable	191
Program designs T flip-flop state machines	192
Circuit vocalizes dialed phone numbers	198
Signal edges set and clear D flip-flop	200
MOSFET switches memory-supply current	202

Continued on page 9

Cahners Publishing Company, A Division of Reed Publishing USA ☐ Specialized Business and Consumer Magazines for Building & Construction ☐ Foodservice & Lodging ☐ Electronics & Computers ☐ Interior Design ☐ Book Publishing & Libraries ☐ Printing ☐ Medical/Health Care ☐ Manufacturing ☐ Industrial/Research Technology ☐ Child Care & Development



# ~~1600~~ 1400 PROGRAMMABLE REASONS TO MOVE UP TO THE 29B.

With support for an additional 200 devices, the 29B Universal Programming System continues to program virtually every device on the market, including the latest one megabit EPROMs and PLDs in PLCC packages. And the 29B continues to support more devices than any other programmer, because no one is more committed to keeping pace with the semiconductor manufacturers than Data I/O®.

**THE 29B GIVES YOU A PROGRAMMING FUTURE.** While the 29B supports more than 1600 devices, you don't have to buy support for every device all at once. Its modular system of paks gives you the flexibility to build a universal programming system at your own pace—whether

gradually or all at once. For example, you can start with gang and set programming for EPROMs and EEPROMs. Later, expand your system by adding logic or bipolar PROM programming.

**MANUFACTURER-APPROVED ALGORITHMS FOR RELIABILITY.** The 29B provides manufacturer-approved algorithms for superior programming. So, whether you operate the system in the stand-alone mode, from a terminal, or from a personal computer using PROMlink™ programmer interface software, you're guaranteed reliable, trouble-free programming and maximum yields. It's this dedication to superior performance and complete device support that's made the 29B the leader, year after year.

## UPGRADE

For a limited time only, you'll receive a credit towards a new 29B mainframe, UniPak 2B™, or GangPak™ when you upgrade your equivalent Data I/O equipment, including the 17, 19, 100A or 29A mainframe; UniPak; or 24/28-Pin Gang Module.

## TRADE IN

Or trade in any other programmer (from any manufacturer), and you'll receive a credit towards the 29B Memory, Logic, or Gang Programming System.

Call to find out exactly how much your programmer is worth. But hurry! This offer ends December 31, 1987.

**1-800-247-5700**  
Dept. 451

**Data I/O Corporation** 10525 Willows Road N.E., P.O. Box 97046, Redmond, WA 98073-9746, U.S.A. (206) 881-6444/Telex 15-2167  
**FutureNet** 9310 Topanga Canyon Boulevard, Chatsworth, CA 91311-5728 (818) 700-0691/Telex 910-494-2681  
**Data I/O Canada** 6725 Airport Road, Suite 302, Mississauga, Ontario L4V 1V2 (416) 678-0761/06968133  
**Data I/O Europe** World Trade Center, Stravinskylaan 633, 1077 XX Amsterdam, The Netherlands (20) 622866/Telex 16616 DATA IO NL  
**Data I/O Japan** Sumitomoseimei Higashishinbashi Bldg., 8F, 2-1-7, Higashi-Shinbashi, Minato-ku, Tokyo 105, Japan (03) 432-6991/Telex 2522685 DATA IO J

©1987 Data I/O Corporation.

# DATA I/O

**VP/Publisher**  
F Warren Dickson

**VP/Associate Publisher/Editorial Director**  
Roy Forsberg

**Editor**  
Jonathan Titus

**Assistant Managing Editor**  
Joan Morrow

**Special Projects**  
Gary Legg

**Home Office Editorial Staff**  
275 Washington St, Newton, MA 02158  
(617) 964-3030

Tom Ormond, *Senior Editor*  
Deborah Asbrand, *Associate Editor*  
Joanne Clay, *Associate Editor*  
Tarlton Fleming, *Associate Editor*  
John A Gallant, *Associate Editor*  
Clare Mansfield, *Associate Editor*  
Dave Pryce, *Associate Editor*  
Cynthia B Rettig, *Associate Editor*  
Charles Small, *Associate Editor*  
Dan Strassberg, *Associate Editor*  
Chris Terry, *Associate Editor*  
Jim Wiegand, *Associate Editor*  
Ron Gilbert, *Staff Editor*  
Valerie Lauzon, *Staff Editor*  
Helen McElwee, *Staff Editor*  
Steven Paul, *Senior Production Editor*

**Editorial Field Offices**  
Margery S Conner, *Regional Editor*  
Los Osos, CA: (805) 528-0833  
Doug Conner, *Regional Editor*  
Los Osos, CA: (805) 528-0864  
Bob Cushman, *Special Features Editor*  
Port Washington, NY: (516) 944-6524  
Steven H Leibson, *Regional Editor*  
Boulder, CO: (303) 494-2233  
J D Mosley, *Regional Editor*  
Arlington, TX: (817) 465-4961  
David Shear, *Regional Editor*  
San Jose, CA: (408) 997-5452  
Maury Wright, *Regional Editor*  
San Diego, CA: (619) 748-6785  
Peter Harold, *European Editor*  
0603-630782  
(St Francis House, Queens Rd,  
Norwich, Norfolk NR1 3PN, UK)

**Contributing Editors**  
Robert Pease, Bob Peterson,  
Don Powers, Bill Travis

**Editorial Services**  
Kathy Leonard, *Office Manager*  
Loretta Curcio, Nancy Weiland,  
Sharon Gildea

**Art Staff**  
Kathleen Ruhl, *Art Director*  
Ken Racicot, *Assistant Art Director*  
Chin-Soo Chung, *Graphic Designer*  
Cathy Filipski, *Graphic Designer*

**Production/Manufacturing Staff**  
William Tomaselli, *Production Supervisor*  
Donna Pono, *Production Manager*  
Janice Dow, *Production Assistant*  
Andrew A Jantz, *Production Assistant*  
Diane Malone, *Composition*

**Graphics Director**  
Norman Graf

**VP/Production/Manufacturing**  
Wayne Hulitzky

**Director of Production/Manufacturing**  
John R Sanders

**Director of Research**  
Deborah Virtue

**Marketing Communications**  
Janice Molinari, *Manager*  
Jennifer Ware, *Communications Manager*  
Corie Rand, *Promotion Coordinator*  
Anne Foley, *Promotion Assistant*

## EDITORIAL

47

As electronic systems become more complex, standards become less standard, which leads to trouble.

## NEW PRODUCTS

Integrated Circuits . . . . .	207
Components & Power Supplies . . . . .	215
Computers & Peripherals . . . . .	224
CAE & Software Development Tools . . . . .	255
Test & Measurement Instruments . . . . .	261

## LOOKING AHEAD

285

PC-board market to grow at 8% average rate per year. . . More US companies plan for crisis communications.

## DEPARTMENTS

News Breaks . . . . .	21
News Breaks International . . . . .	24
Signals & Noise . . . . .	33
Calendar . . . . .	40
Readers' Choice . . . . .	109
Leadtime Index . . . . .	112
Literature . . . . .	273
Business/Corporate Staff . . . . .	275
Career Opportunities . . . . .	276
Advertisers Index . . . . .	282

Professional Issues will return next issue.



### SINGLE PRECISION WHETSTONE LEAGUE



INMOS.  
IMS T800 TRANSPUTER.  
4.6 MEGAWHETSTONES.



INTEL.  
386/387 16 MHz  
1.8 MEGAWHETSTONES.

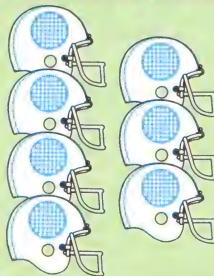


MOTOROLA.  
68020/68881 20 MHz  
1.5 MEGAWHETSTONES.



DEC.  
VAX 11/780/FPA  
1.1 MEGAWHETSTONES.

### DOUBLE PRECISION WHETSTONE LEAGUE



ONE T800 TRANSPUTER GIVES  
2.5 DOUBLE PRECISION  
MEGAWHETSTONES...  
SO WHEN IT COMES TO  
PROCESSING POWER SEVEN  
INMOS T800 CHIPS COULD  
GIVE THE MIGHTY CRAY T3E,  
RATED AT 16.1 MEGAWHETSTONES  
A REAL RUN FOR ITS MONEY!



# MORE MULTIPROCESSOR MUSCLE. MORE RAW PERFORMANCE.

When you're out in the trenches fighting it out with ordinary microprocessors, running out of muscle is all too easy. That's why you should look to the new T800 Transputer from INMOS.

The T800 is the fastest 32-bit, single chip, floating-point microprocessor available today. A quick glance at its statistics will show why nothing else is in its league...

32-bit enhanced RISC processor...64-bit on-chip IEEE floating-point processor...4K Bytes on-chip 50ns static RAM...Four 20 MBits/sec interprocessor communication links...Eight independent DMA engines. All on a single chip capable of sustained 1.5 MFLOPS...and 4.6M Whetstones!

And, if that's not enough raw power, the T800's links allow multiprocessor systems to be constructed quickly and easily - giving you 6 MFLOPS with four T800's...30 MFLOPS with 20...150 MFLOPS with 100...In fact, there's no limit to the number of Transputers you can use!

Programming Transputers couldn't be easier, with compilers for C, Fortran and Pascal, and the world's first concurrent programming language OCCAM.

Want to turbocharge your current system? No problem. Our exclusive Link Adaptor IC's allow Transputers to be connected to other

microprocessors or peripherals.

Other team members include the pin compatible T414 Transputer, offering lower cost, 10 MIP performance and 0.75M Whetstones. Lined-up to provide all the I/O processing you need, the T212 16-bit Transputer is the ideal high performance controller and the M212 Disk Processor combines disk controller hardware and a Transputer on a single chip, supporting both Winchester and floppy disks. And the C004 Link Switch makes the design of software reconfigurable multiprocessor systems as easy as kicking an extra point.

Whatever field you're in - from real-time distributed systems to high-performance graphics, from fault-tolerant systems to robotics, Transputer technology can give you scalable performance at a cost you can afford.

Transputers are manufactured using an advanced 1.5 micron CMOS process which keeps the power consumption under one watt. So your system stays cool while under fire.

Transputers to MIL-STD 883C will be available in the first half of 1988.

If this all sounds like your kind of game, put the ball in play by contacting your local INMOS sales office today. And get ready to score.

DESCRIPTION			PERFORMANCE		AVAILABILITY		PACKAGE
Part No.	Word Length	Clock MHz	Integer Dhrystones	Floating Point Whetstones	Commercial	Military	
IMS T800-20	32-Bit	20	9500	4.6 Million	Now	Q2 88	84 PGA
IMS T414-20	32-Bit	20	9500	0.75 Million	Now	Q2 88	84 PGA
IMS T212-17	16-Bit	17	8000	-	Now	Q2 88	68 PGA
IMS T212-20	16-Bit	20	9500	-	Now	Q2 88	68 PGA
IMS M212-17	16-Bit	17	8000	-	Now	-	68 PGA
NETWORK SUPPORT PRODUCTS					AVAILABILITY		PACKAGE
Part No.	Description	Communication Speed			Commercial	Military	
IMS C004	Software configurable 32 way link switch	10 + 20 MBits/sec			Now	Q2 88	84 PGA
IMS C011	Link to system bus	10 + 20 MBits/sec			Now	-	24 Pin DIP
IMS C012	Link to system bus	10 + 20 MBits/Sec			Now	Q2 88	24 Pin DIP

## THE TRANSPUTER TEAM



INMOS, Colorado Springs, Colorado 80935. Tel. (303) 630-4000.

Orange County - 714-957-6018  
Santa Clara - 408-727-7771

Denver - 303-252-4100  
Minneapolis - 612-932-7121

Dallas - 214-490-9522  
Boston - 617-366-4020

Baltimore - 301-995-6952  
Atlanta - 404-242-7444

- ☐ Send me information on the Transputer Team. ☐ Send me the Transputer White Pages, a listing of third-party manufacturers' transputer-based products and services.
- ☐ Please have a Field Applications Engineer call. ☐ Please have a salesman call.

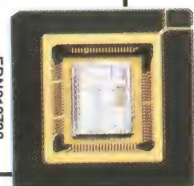
Name \_\_\_\_\_ Title \_\_\_\_\_

Company \_\_\_\_\_ Address \_\_\_\_\_

\_\_\_\_\_ Zip \_\_\_\_\_ Tel \_\_\_\_\_

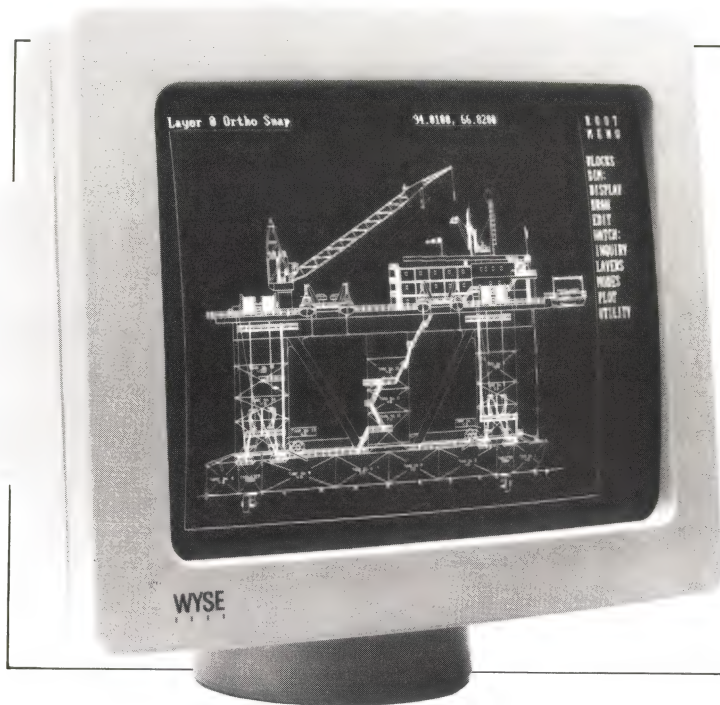
INMOS Transputer  and IMS are trademarks of the INMOS Group of Companies.

EDN010788



CIRCLE NO 138

# Wyse takes the high cost out of high resolution.



**At \$999, the WY-700 Graphics Subsystem is easily affordable. And its 1280 x 800 resolution makes the best of software packages like these:**

#### DESKTOP PUBLISHING

Ventura Publisher  
PageMaker/PC  
Frontpage  
DeskSet  
Pagemaster  
Rim System  
Compound Document Processor  
Display Ad Make-up System  
AdvanTex

#### COMPUTER-AIDED DESIGN

AutoCAD  
Cadvice  
In-A-Vision  
Generic CADD  
VersaCAD ADVANCED  
Workview  
Procad PC  
P-CAD Systems

#### GRAPHIC SYSTEM TOOLS

MS-Windows  
GEM  
MetaWindows  
HALO  
KEE PC

#### GENERAL PC SOFTWARE

Lotus 1-2-3  
Symphony  
PC-Paintbrush

Wyse raises the standards for high resolution graphics, while lowering the cost.

Now you can have high resolution and full IBM software compatibility.

So Desktop publishing applications can get the screen treatment they deserve. You can run spreadsheets like Lotus 1-2-3 with four times more data displayed on the screen. Computer-Aided Design packages can deliver their full potential. And Graphics-based pc environments finally have the high resolution they were made for.

You can do it all on the WY-700. A complete system, monitor and board, for just \$999. With a large 15-inch display, full tilt and swivel, and a crisp 1280 x 800 pixel resolution.

The WY-700. It's your best solution for high resolution.

Write Wyse Technology, Attention: Marcom Dept. 700,

3571 N. First Street, San Jose, CA 95134. Or call toll-free, today, for more information.

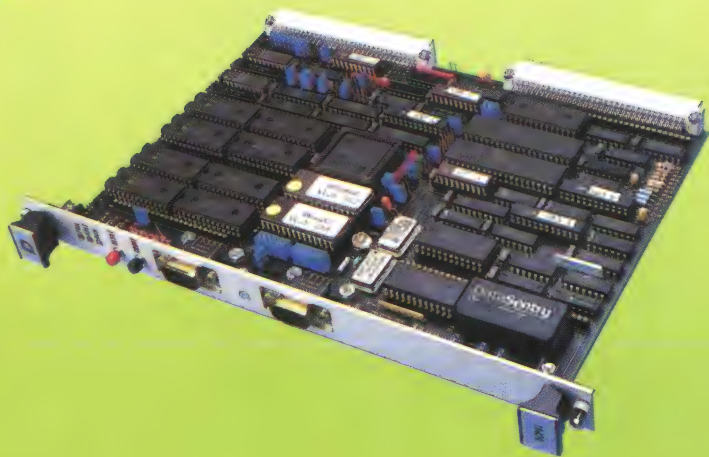
Call 1-800-GET-WYSE

## WYSE

YOU NEVER REGRET A WYSE DECISION.



# The Highs and Lows.



Sometimes there's more to high technology than just the highs. A good CPU board delivers high quality, high performance, and high speed. A great CPU board can deliver all that with low power consumption and low heat dissipation—all at a low cost. That's why Dynatem's DCPU1 is a great CPU Board — a perfect blend of the highs and lows. The DCPU1 achieves this perfect blend by combining 100% CMOS technology on the VMEbus with a high performance I/O oriented board.

With two serial ports, 40 programmable parallel I/O lines plus three 16-bit timers, and a real-time clock/calendar, the DCPU1 meets the performance challenges of many industrial applications.

Round out the highs and lows with a feature that makes development on the DCPU1 surprisingly easy—you can prepare programming on an IBM (or compatible) PC XT or AT and download to the module—and you've got a great CPU Board.

You've got Dynatem's DCPU1.

- High Quality
- High Performance
- High Speed
- Low Power
- Low Temperature
- Low Cost

## 100% CMOS VME.

■ I/O oriented CPU module with two serial ports, 40 programmable parallel lines, three 16-bit timers and a real-time clock/calendar.

■ 100% CMOS VME board with low power, low heat dissipation (CMOS 68000 CPU at 8, 10, 12.5 MHz)

■ Programs can be prepared on an IBM or compatible PC and down loaded

■ Up to 512 Kbytes no-wait, dual ported static RAM, 128 Kbytes PROM

■ VME master and slave, receive and generate 7 levels of interrupt

■ Low cost



Dynatem Inc., 19 Thomas, Irvine, CA 92718  
Call toll-free 1-800-543-3830  
In California 714-543-3830  
TWX 910 595 2603

# MACSYMA

automates symbolic mathematics.

And yields enormous improvements in productivity,  
accuracy and modeling power.

**MACSYMA** combines exact solutions, symbolic approximations, and numerical methods into a powerful automated approach to scientific and engineering computing. Major benefits include:

- **Improved Productivity:** For many types of computations MACSYMA can increase your productivity by 10 to 100 times.  
*It is that revolutionary.*
- **Increased Accuracy:** Manual computational errors are virtually eliminated. Use exact or approximate symbolic solutions in place of less accurate numerical ones.
- **Enhanced Mathematical Power:** You can dare to perform automated computations which you would not believe practical using traditional methods.

## Wide Range of Capabilities

**MACSYMA** offers the widest range of capabilities for combined symbolic and numerical mathematics of all commercially available software.

- Algebra and Trigonometry
- Calculus and Differential Equations
- Symbolic Approximation Methods
- Numerical Analysis
- Graphics

## Available on Many Computer Systems

- Apollo
- Masscomp
- SUN-2 and SUN-3
- Symbolics 3600™ series
- Vax family

For an information kit about all the ways MACSYMA can work for you, just call

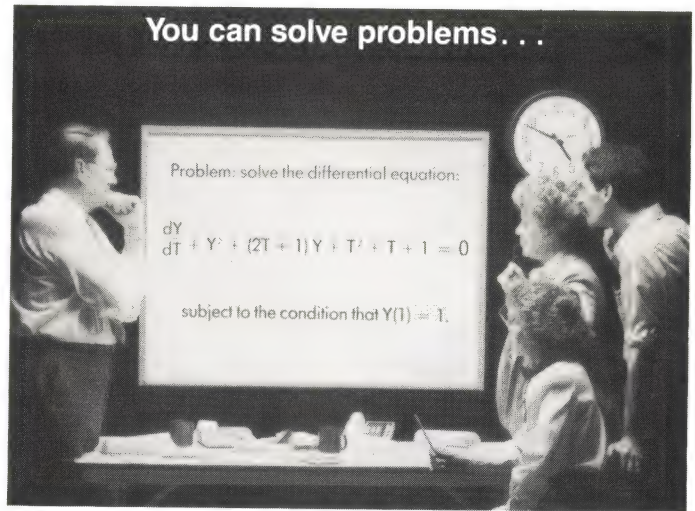
**1-800-MACSYMA.**

In Mass., (617) 621-7770.

Computer-Aided Mathematics Group  
Dept. M-ED9  
Symbolics, Inc.  
Eleven Cambridge Center  
Cambridge, MA 02142

# MACSYMA

The most comprehensive software for  
mathematical computing.



## Symbolically. . .

```
(C1) DEPENDS(Y,T)$
(C2) DIFF(Y,T) + Y^2 + (2*T+1)*Y + T^2 + T + 1;
(D2) dY/dT + Y^2 + (2*T+1)*Y + T^2 + T + 1
(C3) SOLN:ODE(D2,Y,T);
(D3) Y = - (%C*T*%E^T - T - 1) / (%C*%E^T - 1)
(C4) SOLVE(SUBST([Y=1, T=1],D3),%C),NUMER;
(D4) [%C = 0.5518192]
(C5) SPECIFIC.SOLN:SUBST(D4,SOLN);
(D5) Y = - (0.5518192*T*%E^T - T - 1) / (0.5518192*%E^T - 1)
```

## and Numerically.

```
(C6) FORTRAN(D5)$
      Y = - (0.5518192*T*EXP(T) - T - 1)
1      / (0.5518192*EXP(T) - 1)
```

symbolics™

What do you need to build  
on a rough application concept?



# AT&T. The comp



# ponents of success.



Whether you're building a visionary home—or a breakthrough product or system—getting from concept to completion demands more than bricks and mortar, or metal and silicon.

There are other components that can make a critical difference in meeting your market window on time, and on budget.

We call them the components of success—ready for immediate delivery from AT&T.

**The component of commitment: here today, here tomorrow.**

AT&T is in the components business to stay. We have formed a separate unit, AT&T Microelectronics, to bring our more than 100 years of electronic components experience to the marketplace. And, we have the capital, people, and technical savvy to meet our commitment to the future.

**The component of innovation: AT&T Bell Labs.**

Count on Bell Laboratories to help make your 'blue-sky' designs a reality. With everything from DSPs and optical data links, to custom designed products such as ASICs, multilayer boards, and power supplies. And throughout planning and manufacturing, count on AT&T to keep your product up to the minute with the latest Bell Labs advances.

**The component of quality.**

Through our Integrated Quality System, Bell Labs engineers work with our quality professionals to meet customer-defined criteria. At AT&T quality is

our history—and our future.

**The component of management involvement.**

AT&T Microelectronics gives you total support, right up to its president, Bill Warwick. If our solutions aren't on the money, call him at 1 201 771-2900.

**The component of quick response.**

With 12 plants and an extensive network of design centers and sales offices worldwide, AT&T is ready to meet your volume demand for components. Ready with everything you need to get ideas off the ground and in the market—successfully.

To learn why AT&T is more than ever the right choice, just give us a call.

**DIAL 1 800 372-2447**

**AT&T Microelectronics  
Major Product Lines:**

ASICs  
Digital Signal Processors  
Communication ICs  
32-bit Microprocessors  
and Peripherals  
Solid State Relays  
Multilayer Circuit Boards  
HICs  
Optical Data Links  
Fiber Optic Components  
Power Products  
Transformers and Inductors  
Wound Film Capacitors

© 1987 AT&T



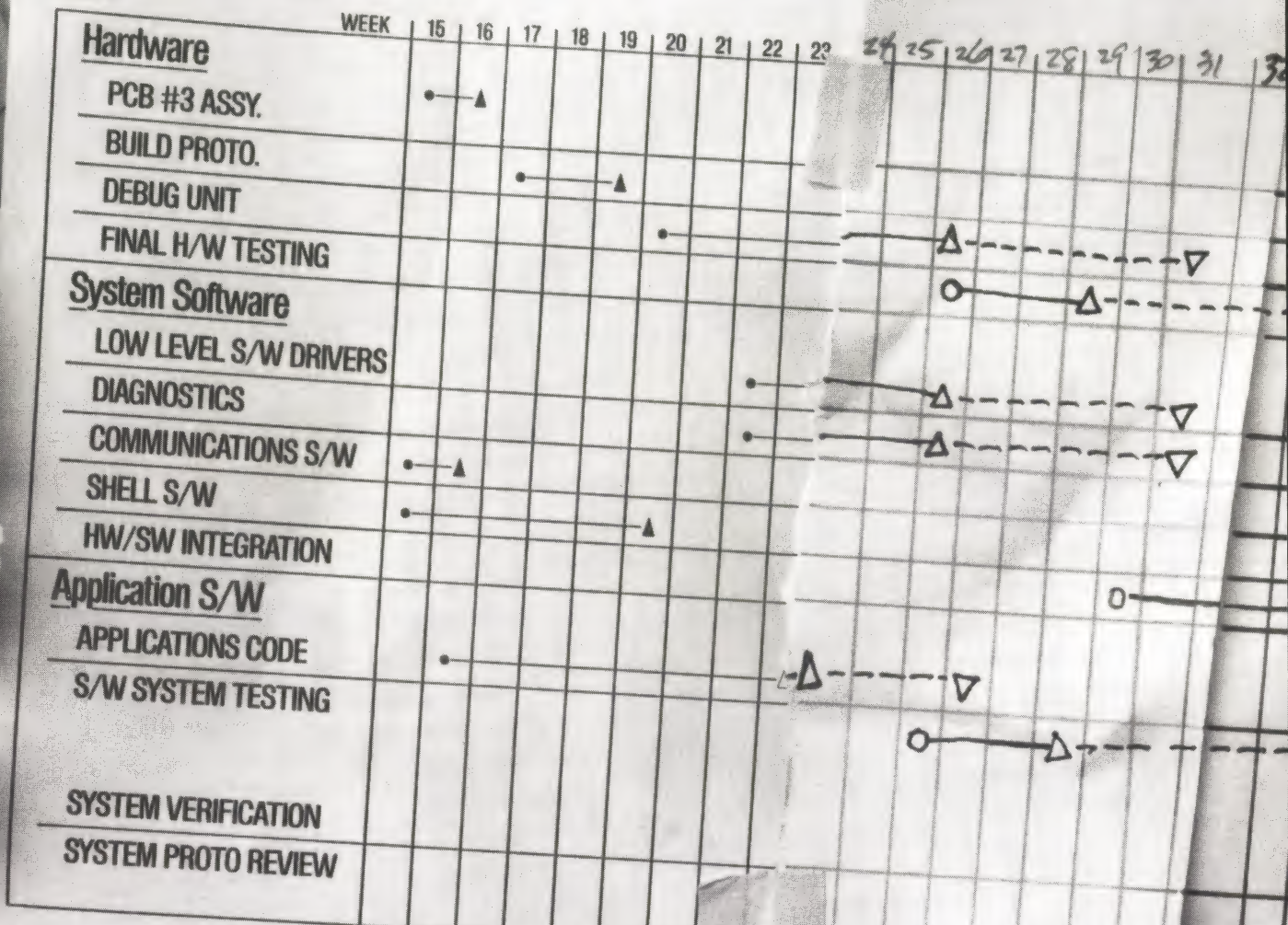
**AT&T**

**The right choice.**

**CIRCLE NO 133**

# It's your choice.

## PRODUCT DEVELOPMENT SCHEDULE PAGE 2



Let's face it.

Slipped development schedules and budget overruns can mean lost opportunities. Yet many traps that seriously delay a development schedule are quite complex, especially when they are compounded by problems that arise in cross development work.

Like not knowing whether the errors you are getting from your prototype processor are real. Or losing bugs in the cracks between your development system and the prototype.

Fortunately, the answer to these complex problems is simpler than you might think. Because now Applied Microsystems offers what we call performance packages: complete, fully integrated development solutions, designed to meet your development requirements and to detect even subtle problems quickly.

### Performance Packages that Live Up to Their Name.

Each package includes a powerful in-circuit emulator, the only tool that can

successfully bridge the gap between host computer and prototype. With features like complex triggering, reliable memory, built-in target diagnostics, I/O simulation, and special interrupt handling.

And to complement the power of our emulators, we provide software tools that work with a variety of platforms and languages.

Whichever package you choose, you're getting the highest performance

# Invest now or pay later.

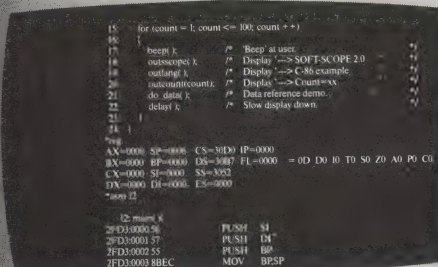
are designed for any language producing complete Intel OMF information.

A PC-based, in-circuit source level debugger and simulator are closely cou-

remote control and simulation of I/O; plus user-definable windows for viewing registers, stacks and variables

## High-speed Symbolic Debugging for Intel, Motorola and Zilog Microprocessors

Our VALIDATE/ES DRIVER package includes easy-to-use (menu-driven and remote control) software that smoothly links the host functions to the ES 1800 emulator. This allows the upload and download of programs, symbol tables and command files.

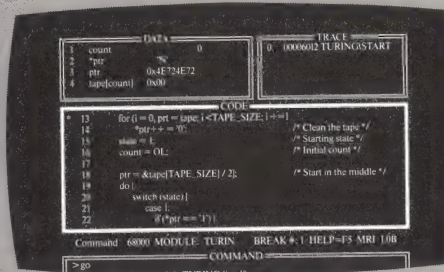


pled with our ES 1800 emulator. You can use commands to examine variables on the fly, check contents of registers, and determine current position in code. And real-time trace is displayed as source level statements, machine instructions or bus cycles.

The packages also include a logic state analyzer probe, and provide up to 2 Megabytes of overlay memory plus full protect mode support for the 80286.

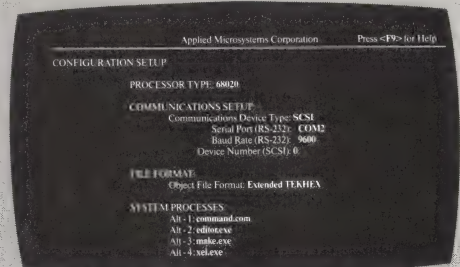
## Source Level Debugging for Motorola Microprocessors

The window-oriented VALIDATE/XEL package combines our XEI source-level debugger, a simulator and the MCC68K compiler with our ES 1800



emulator. The package also includes a logic state analyzer probe and our well-known SCSI interface option, that significantly decreases download time.

In addition to up to 2 Megabytes of overlay memory, you get target control from your source code; powerful "C" language macros for code patching,



Also included are a logic state analyzer probe; the SCSI option for increasing download speeds by up to 30 times; plus up to 2 Megabytes of overlay memory.

To find out more about 8, 16 or 32-bit development solutions that save money in the long run, write Applied Microsystems Corp., P.O. Box 97002, Redmond, WA 98073-9702. Or call 1-800-426-3925 (In Washington, call 206-882-2000).

In Europe, contact Applied Microsystems Corporation Ltd., Chiltern Court, High Street, Wendover, Aylesbury, Bucks, HP22 6EP, United Kingdom. Call 44-(0)-296-625462.



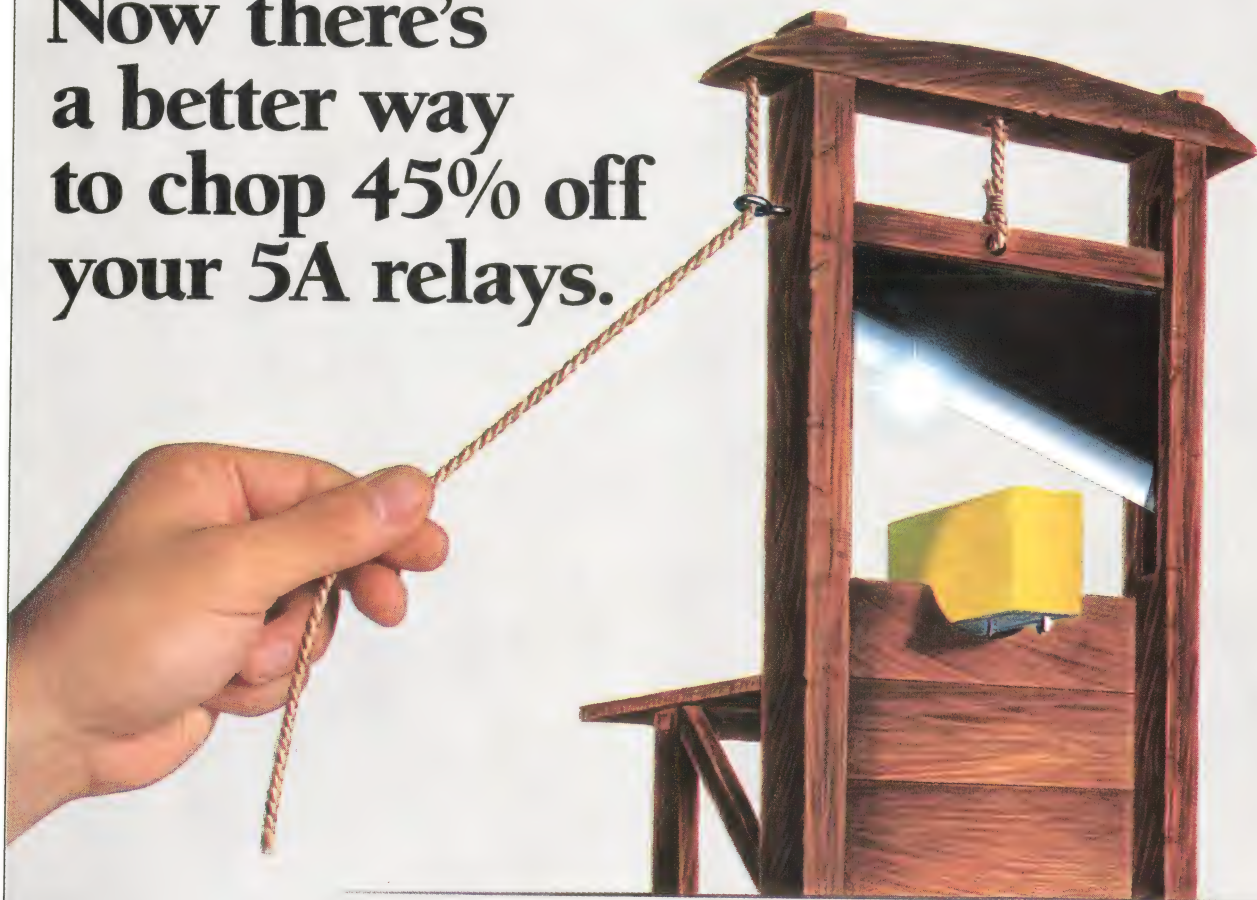
**Applied  
Microsystems  
Corporation**

development tools available.

## Source Level Debugging for Intel Microprocessors

Our VALIDATE/Soft-Scope and VALIDATE/Soft-Scope 286 packages

# Now there's a better way to chop 45% off your 5A relays.



New 5A relay is 45% smaller



Fujitsu's new FBR60 Series 5A miniature control relay gives you virtually the same performance as standard 5A relays. But it's smaller in every dimension. Lightweight, too — only 7 grams.

Automotive systems designers: just think of what you can do with the space you'll save. In wiper control circuits. Power window and seat controls. Antenna motor controls. And more.

And Fujitsu FBR60 relays are the space-saving answers for all kinds of FA and OA applications as well.

## Just take a look at these specifications:

Dimensions:	18.8mm (0.740 in.) x 13.3mm (0.524 in.) x 13.6mm (0.535 in.) (LxWxH)
Weight:	7 grams
Operating Life:	100k operations (min.) at 28VDC-5A
Contact Material:	silver, silver copper, silver cadmium oxide, special silver alloy
Cleaning:	Immersion-cleanable type available

Call your Fujitsu components dealer. He'll show you how Fujitsu's FBR60 Series 5A relays can slim down your circuit designs — without cutting corners on quality.

## FBR60 Series Relay

### FUJITSU MIKROELEKTRONIK GmbH:

Arabella Center 9, OG/A, Lyoner Straße 44-48, D-6000 Frankfurt am Main 71, F.R. Germany Phone: 069-66320 Telex: 0411963 Fax: 069-6632122

### FUJITSU COMPONENT OF AMERICA, INC.:

3320 Scott Blvd., Santa Clara, California 95054-3197, U.S.A. Phone: 408-562-1000 Telex: 910-338-0190 Fax: 408-727-0355

### FUJITSU MICROELECTRONICS PACIFIC ASIA LIMITED:

805, Tsim Sha Tsui Centre, West Wing, 66 Mody Road, Kowloon, Hong Kong Phone: 3-7320100 Telex: 31959 FUJIS HX Fax: 3-7227984

### FUJITSU LIMITED (Electronic Components International Sales Support Div.):

Furukawa Sogo Bldg., 6-1, Marunouchi 2-chome, Chiyoda-ku, Tokyo 100, Japan Phone: National (03) 216-3211 International (Int'l Prefix) 81-3-216-3211 Telex: 2224361 Fax: (03) 216-9771



# NEWS BREAKS

EDITED BY JOANNE CLAY

## **SMD/SME DISK CONTROLLER FITS SUN WORKSTATIONS**

Capable of controlling as many as four SMD/SME disk drives with serial data rates as high as 24 MHz and burst data rates in excess of 30M bytes/sec, the Rimfire 3220 VME Bus controller from Ciprico (Plymouth, MN, (612) 559-2034) also plugs directly into your Sun workstation without an intervening adapter card. The 3220 has the same 367×400-mm dimensions that Sun's triple-high, triple-wide plug-in cards have. This controller has an 80186  $\mu$ P for cache control, a 512k-byte configurable cache memory that prereads data across track and cylinder boundaries, and as many as seven circular command queues that provide a software interface for communication with Sun's SunOS or the Unix BSD 4.2 operating system. You can purchase single units for \$3495.—J D Mosley

## **MORE COMPANIES JUMP ONTO THE RISC BANDWAGON**

MIPS Computer Systems (Sunnyvale, CA, (408) 720-1700), creator of the R2000 RISC-based  $\mu$ P, has licensed Integrated Devices Technology (Santa Clara, CA, (408) 727-6116), Performance Semiconductor (Sunnyvale, CA, (408) 734-9000), and LSI Logic (Milpitas, CA, (408) 433-8000) to build the device. Performance Semiconductor and IDT will produce off-the-shelf products; LSI Logic will make the R2000 available as a standard product and also include it in its library for custom applications. All three licensees will be marketing MIPS Computer Systems' advanced RISC (reduced instruction set computer) software environment along with the chip set. The chip set consists of the CPU and a floating-point coprocessor. You can expect the devices to be in production by mid-1988.—David Shear

## **BYTE-WIDE STATIC RAM SPECS 85-NSEC ACCESS TIME**

To cut down on the amount of clocking or timing logic in your next design, consider using the 256k-bit MCM60256 CMOS static RAM from Motorola (Austin, TX, (512) 928-6705). Organized as 32k 8-bit words, Motorola's 256k-bit MCM60256 CMOS static RAM has two separate chip-enable pins to accommodate either active-low or active-high signals. An optional low-power version of this chip also provides a power-saving mode. Housed in a 28-pin, 600-mil DIP, this memory device is pin compatible with the manufacturer's 2764 EPROM family. You can order these devices with 85-, 100-, or 120-nsec access times. Prices range from \$18.78 (500) for the 120-nsec, standard-power model to \$27.03 (500) for the 85-nsec, low-power version.—J D Mosley

## **HYBRID INCORPORATES PLD TO RESURRECT OBSOLETE IC**

When National Semiconductor (Santa Clara, CA, (408) 721-5000) made its DM8512 flip-flop obsolete, the company inadvertently destroyed the original artwork, without which no more of the devices could be manufactured. Unfortunately, at least one company needed that IC to maintain existing government systems; a 20-pin PLD would not fit into the original 16-pin socket. To solve the problem, Cer-Tek (El Paso, TX, (915) 778-1555) incorporated both a 74LS74 and a PAL14H4 die in one package, creating a hybrid circuit that's compatible with the original device. National Semiconductor supplies preprogrammed PLD dies to Cer-Tek for the hybrid. L J Floyd, Cer-Tek's president, estimates that his company can create similar replacements for other obsolete parts for less than \$20 (1000).—Steven H Leibson

# NEWS BREAKS

---

## **PIN-COMPATIBLE FLOATING-POINT CHIP SET**

Integrated Device Technology (Santa Clara, CA, (408) 727-6116) has introduced a floating-point chip set that's pin compatible with the Weitek 1264/1265. The IDT721264/IDT721265 chip set uses a 30-nsec clock to perform 32- and 64-bit ALU operations at 16.7M flops, 32-bit multiplications at 16.7M flops, and 64-bit multiplications at 8.3M flops. Besides including the Weitek standard ALU functions, the chip set has an instruction that supports the Newton-Raphson algorithm. Each device comes in a 144-lead pin-grid array; the chip set costs \$406 (100).—David Shear

## **PATTERN GENERATOR TEAMS UP WITH YOUR LOGIC ANALYZER**

The PI-6500 pattern generator from Pulse Instruments (Torrance, CA, (213) 515-5330) can provide any logic analyzer with stimulus and response capabilities. The pattern generator offers a maximum of 48 channels with 4k bits of pattern memory behind each channel. For applications requiring deeper pattern memory and fewer channels, you can chain groups of 16 channels together to obtain three channels with 64k bits each of pattern memory. The pattern generator's clock rates can vary from 760 Hz to 25 MHz, allowing you to generate timing sequences with 40-nsec resolution. The skew between any two channels is less than 4 nsec. The output levels are TTL compatible, and they can be 3-state.

You can define as many as 4k subpatterns from the basic pattern memory and then use those subpatterns in a pattern-control program. The triggering function can use the immediate mode or the latched mode; the latched mode waits one to 16 clock periods before triggering on the data. The trigger reactions require nine clock periods plus 170 nsec before the output changes state. The occurrence of a trigger event also produces as many as 256 different flag events that you can use to control your logic analyzer or other functions external to the pattern generator. The pattern generator has 256k bytes of nonvolatile RAM to store patterns and programs. An optional IEEE-488 or RS-232C interface card lets you generate patterns on a computer and send them to the pattern generator. The PI-6500 starts at \$7475.—Doug Conner

## **ADAPTER CONVERTS 68-PIN PGA TO PLCC**

If you're developing a design that will incorporate a device in a 68-lead plastic leaded chip carrier (PLCC), but you can only obtain the device in pin-grid arrays (PGAs), the 308-1846-XX Series adapter from Methode Electronics Inc (Chicago, IL, (312) 867-9600) can solve your problem. The top of the adapter accepts a 68-pin PGA; PLCC leads protrude from the bottom. The adapter is available in 10x10 and 11x11 grid patterns and costs \$265 in production quantities.—Steven H Leibson

# Speed Reading.

A big book, packed full of record breaking, highest performance, lowest power parts.

Required reading for designers who are building faster systems that run cooler, and use less power.

Read all about:

**CMOS high speed SRAM.** From our 7ns 1K to our family of 25ns 64K SRAMs, with 30 + parts in between.

**CMOS high speed PROM.** Reprogrammable, if you wish. In a family with speeds as fast as 25ns and in sizes to 128K.

**CMOS high speed PLD.** Including the fastest, coolest CMOS 22V10 with 25ns quarter power performance, and optional reprogrammable versions.

**CMOS high speed Logic.** Highlighted by our 30ns 16-bit slice, and our 35MHz FIFO family in cool, cool CMOS.

**And read about:** Our expanding military product line. Our QuickPro™ for easy programming and diagnostics using any PC-compatible. Our newest products. And our applications notes.

624 pages of parts and ideas you can use to design faster, cooler systems.

**Yours fast, for a toll-free phone call.**

**1-800-952-6300, ask for Dept. C48**

**1-800-423-4440 (In CA), ask for Dept. C48**

**(32) 2-672-2220 (In Europe). (416) 475-3922 (In Canada).**



CYPRESS  
SEMICONDUCTOR

Cypress Semiconductor 3901 North First Street, San Jose, CA 95134. Phone (408) 943-2666. Telex 821032 CYPRESS SNJ UD. TWX 910-997-0753. QuickPro is a trademark of Cypress Semiconductor.  
©1987 Cypress Semiconductor.

CIRCLE NO 143

# NEWS BREAKS: INTERNATIONAL

---

## **SUBASSEMBLY EASES SOLID-STATE CAMERA DESIGN**

To simplify the design of cameras for surveillance and machine-vision systems, Philips' Component Div (Eindhoven, The Netherlands, TLX 51573) has introduced a camera subassembly that incorporates the company's monochrome solid-state image sensor. In addition to the image sensor, the subassembly includes all the drive, preprocessing, video-processing, and power-supply circuitry necessary to produce a 1V p-p composite-video output. To produce a complete camera, you need only add a suitable lens and camera housing. Options for the subassembly include interlaced or noninterlaced operation, automatic or computer-controlled gain, automatic iris control, internal or external synchronization, and switchable gamma compensation. Versions are available for 525- or 625-line TV systems that meet EIA or CCIR standards. Built on a semirigid pc board, the subassembly folds down to 89×40×45 mm. In OEM quantities, the subassembly starts at around DM 600.—Peter Harold

## **GRAPHICS ADAPTER DRIVES VIDEO MONITORS AND LASER PRINTERS**

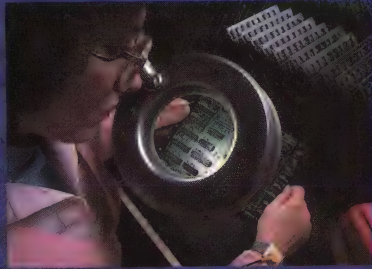
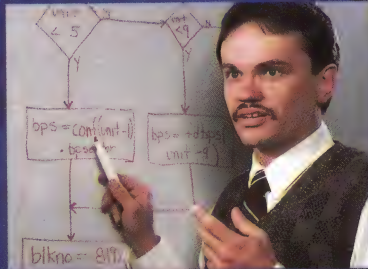
Based on a 20-MHz, 32-bit Inmos T414 or T800 Transputer, the Vincent graphics adapter from Simulation Technology (Oslo, Norway, FAX (02) 156051) provides IBM PC/AT computers with high-resolution graphics and image-processing capabilities. The \$6000 board has as much as 1.5M bytes of video RAM and a color look-up table; it allows you to display 256 gray-scale levels or 256 colors from a palette of 16M colors. Additional on-board RAM (as much as 4M bytes) provides program and data storage, as well as temporary buffers for image information. The board supports screen resolutions as high as 1600×1280 pixels, and most of the video-output characteristics—including the vertical and horizontal scan rates, the number of dots per line, and the number of lines per frame—are software programmable. The board has an AT-bus interface that can operate at 800k bytes/sec. The board's plug-in crystal oscillators allow you to operate it at dot rates as high as 120 MHz. In addition to its RGB video output, the board also has a Canon/PelBox interface for a laser printer or phototypesetter.—Peter Harold

As it appeared in the December 26, 1987, issue, the following item contained some inaccuracies, which made it misleading. The corrected version follows.

## **STEPPER-MOTOR DRIVERS EASE INTERFACE TO MICROCONTROLLERS**

The MTC6017 stepper-motor driver from Mietec (Oudenaarde, Belgium, TLX 85739) is an H-bridge driver that's suitable for controlling the current in one winding of a bipolar stepper motor. Although it's similar to the industry-standard 3717-type driver, the MTC6017 has control codes for its two current-control inputs that maintain a direct (but nonlinear) relationship with the winding current, thereby simplifying control firmware. The driver also includes an on-chip 5V reference for the current-sense comparators. Another device, the MTC6018, targets microstepping applications; it provides a 6-bit on-chip D/A converter for winding-current control. The MTC6017 and MTC6018 will cost around \$2.20 and \$2.50, respectively. They're slated for introduction during the first and the second quarter of 1988, respectively.—Peter Harold

# In our VMEbus & MULTIBUS<sup>®</sup> II controllers, take all three "wares" for granted



## With Ciprico hardware, software, and humanware, you can make a more comfortable decision

We start by taking your time frame for designing a high performance microcomputer or supermicro as seriously as you. You'll receive an intelligent disk or tape controller board for evaluation as your schedule dictates.

That's humanware.

So is the experienced team we assign to help you get your board up and running. And our pledge to get back to you within four working hours any time you contact us during evaluation.

Software you can take for granted is a driver written by our engineering staff to take full advantage of your system's performance.

MULTIBUS is a registered trademark of Intel Corp.

We can provide it with your board.

Visit our plant and you'll see how we develop new boards timely and reliably — with advanced design tools and a large library of proven firmware modules written in "C". Also, we have a comprehensive industry-leading ESD program, burn-in, 100% in-circuit testing, and functional stress testing.

In other words, you'll see you can take it for granted that every board

will arrive on time and ready to work.

(In rare cases, if repair is ever needed, take it for granted that we'll provide 48-hour turn-around.)

You'll even find us easy to work with.



Another thing to take for granted is our R&D commitment to develop the highest performance controllers. One good example is our new Rimfire 3400. This intelligent VMEbus ESDI disk controller features a unique 512 Kbyte intelligent caching architecture and a command queuing software interface. For more information on all Ciprico controllers, for VMEbus and MULTIBUS I & II, contact us now.



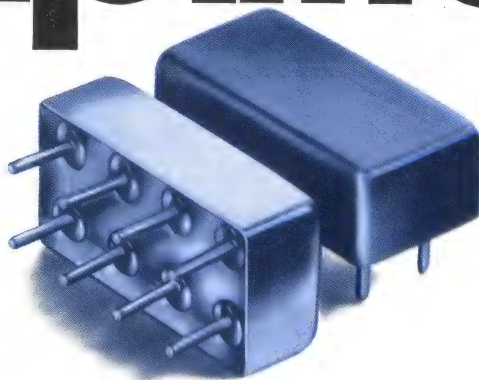
## CIPRICO

2955 Xenium Lane  
Plymouth, MN 55441

CIPRICO LISTENS. AND RESPONDS.

For more information call from your modem **1-800-332-0012** (300-1200 baud, 8 bit, no parity 1 stop bit) and enter the access code **CIPBUS1** when prompted. (In VA call 703-476-5255)

# rugged plug-in amplifiers



**0.5 to 1000 MHz from \$13<sup>95</sup>** (5 to 24 qty)

Tough enough to meet full MIL-specs, capable of operating over a wide  $-55^{\circ}$  to  $+100^{\circ}\text{C}$  temperature range, in a rugged package... that's Mini-Circuits' new MAN-amplifier series. The MAN-amplifier's tiny package (only 0.4 by 0.8 by 0.25 in.) requires about the same pc board area as a TO-8 and can take tougher punishment with leads that won't break off. Models are unconditionally stable and available covering frequency ranges 0.5 to 500MHz and 0.5 to 1000MHz, and NF as low as 2.8dB.

Prices start at only \$13.95, **including** screening, thermal shock  $-55^{\circ}\text{C}$  to  $+100^{\circ}\text{C}$ , fine and gross leak, and burn-in for 96 hours at  $100^{\circ}\text{C}$  under normal operating voltage and current.

Internally the MAN amplifiers consist of two stages, including coupling capacitors. A designer's delight, with all components self-contained. Just connect to a dc supply voltage and get up to 28dB gain with +9dBm output.

**The new MAN-amplifier series...**  
another Mini-Circuits' price/performance breakthrough.

MODEL	FREQ. RANGE (MHz) $f_L$ to $f_U$	GAIN dB min flatness††	MAX. OUT/PWR† dBm	NF dB (typ)	DC PWR 12V, mA	PRICE \$ ea. (5-24)
MAN-1	0.5-500	28 1.0	8	4.5	60	13.95
MAN-2	0.5-1000	19 1.5	7	6.0	85	15.95
MAN-1LN	0.5-500	28 1.0	8	2.8	60	15.95
◊MAN-1HLN	10-500	10 0.8	15	3.7	70	15.95

†† Midband  $10f_L$  to  $f_U/2$ ,  $\pm 0.5\text{dB}$

† 1dB Gain Compression

◊ Case Height 0.3 In.

Max input power (no damage) +15dBm; VSWR in/out 1.8:1 max.

finding new ways...  
setting higher standards

**Mini-Circuits**

A Division of Scientific Components Corporation  
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500  
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156



# *value-packed* filters **\$9.95** from

dc to 3GHz

- less than 1dB insertion loss over entire passband
- greater than 40dB stopband rejection
- 5 section, 30dB per octave roll-off
- VSWR less than 1.7 (typ)
- over 100 models, immediate delivery
- meets MIL-STD-202
- rugged hermetically sealed package (0.4 x 0.8 x 0.4 in.)
- BNC, Type N, SMA available

finding new ways...  
setting higher standards

**Mini-Circuits**

A Division of Scientific Components Corporation  
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500  
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156

LOW PASS	Model	*LP-	10.7	21.4	30	50	70	100	150	200	300	450	550	600	750	850	1000
Min. Pass Band (MHz) DC to			10.7	22	32	48	60	98	140	190	270	400	520	580	700	780	900
Max, 20dB Stop Frequency (MHz)			19	32	47	70	90	147	210	290	410	580	750	840	1000	1100	1340

Prices (ea.): P \$9.95 (6-49), B \$24.95 (1-49), N \$27.95 (1-49), S \$26.95 (1-49)

HIGH PASS	Model	*HP-	50	100	150	200	250	300	400	500	600	700	800	900	1000
Pass Band (MHz)		start, max.	41	90	133	185	225	290	395	500	600	700	780	910	1000
		end, min.	200	400	600	800	1200	1200	1600	1600	1600	1800	2000	2100	2200
Min. 20dB Stop Frequency (MHz)			26	55	95	116	150	190	290	365	460	520	570	660	720

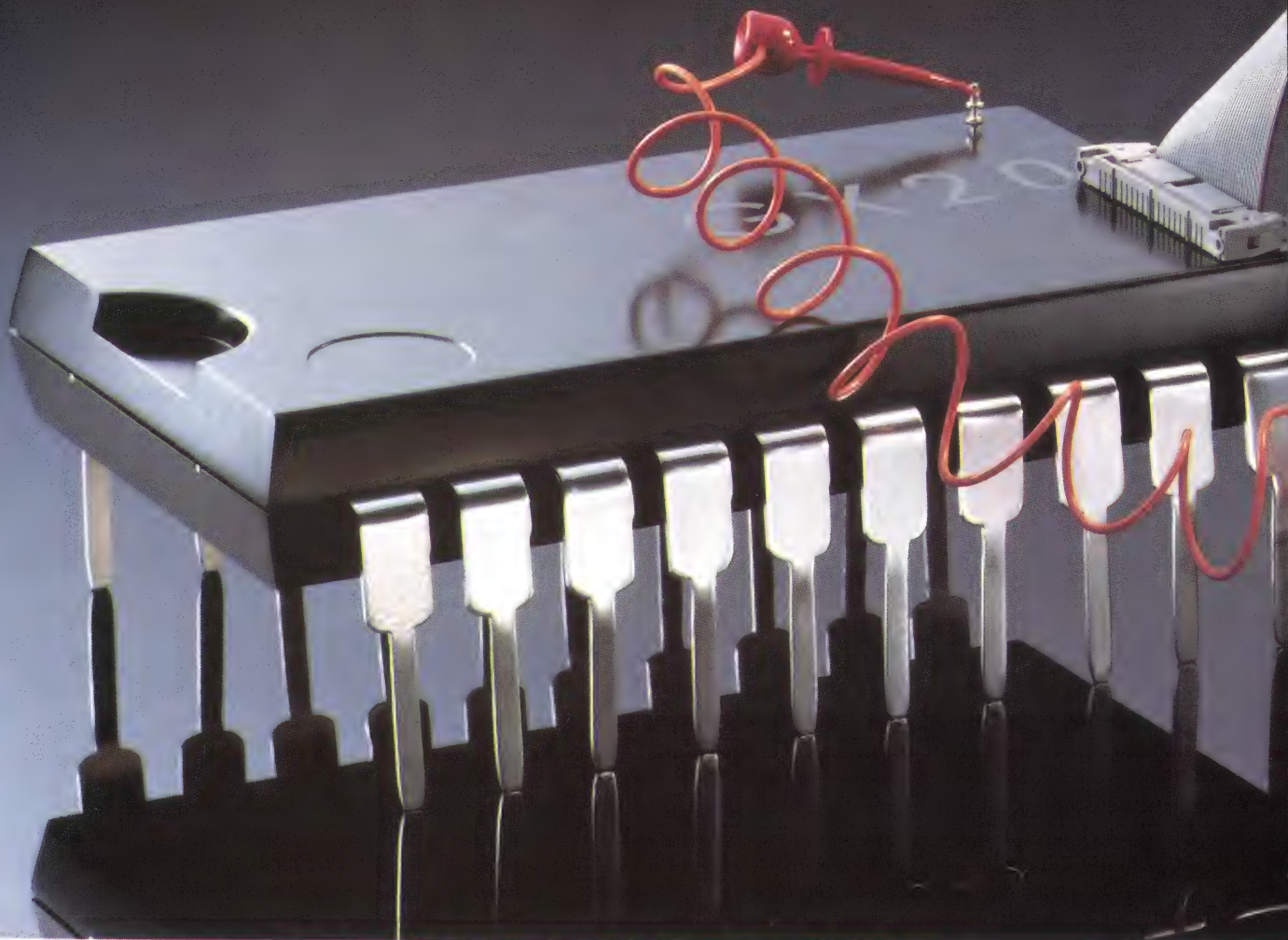
Prices (ea.): P \$12.95 (6-49), B \$27.95 (1-49), N \$30.95 (1-49), S \$29.95 (1-49)

\*Prefix P for pins, B for BNC, N for Type N, S for SMA

example: [PLP-10.7](#)

CIRCLE NO 142

C105 REV.D



## You wouldn't do this with your Analog VLSI devices.

You'll have to if you go to most ATE companies for a solution to today's sophisticated "system silicon" testing problems. Because all you'll get is a make-shift tester. And that means resigning yourself to man-months of custom hardware work integrating analog and digital instrumentation. And putting up with the long hours of low-level software development that go with custom solutions. Worse, you can expect these delays to cut your chances of getting your product to market on time.

Teradyne now has a simple answer to this complex testing problem. The A500 Analog VLSI Test System. It's the first of a new generation of systems specifically for AVLSI "system silicon" devices. A test system that can help you cut critical product development time by months or even years.

### **One Test System, Once and for All**

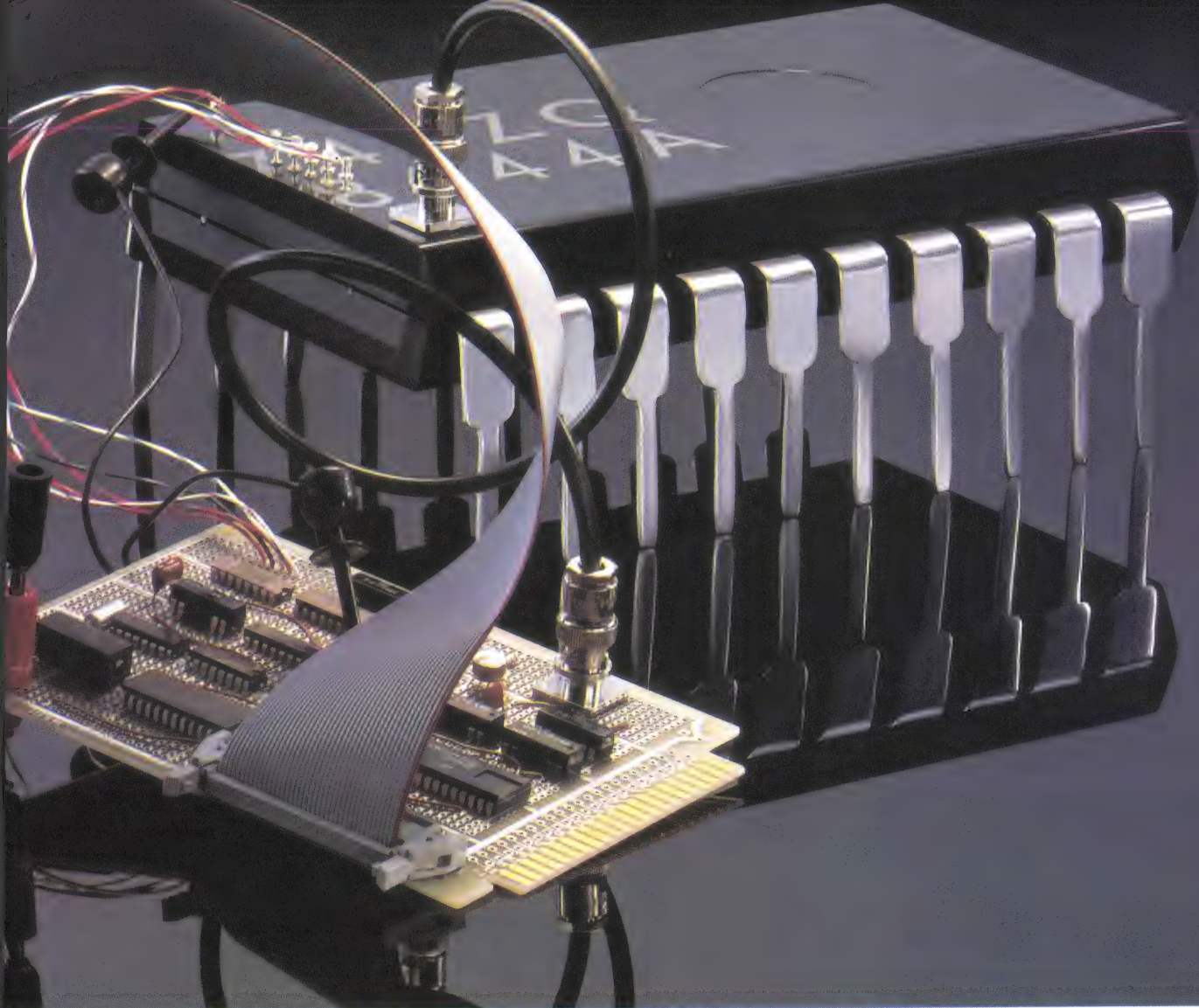
With AVLSI devices you won't get fast design feedback, unless you test individual components—the

"building blocks" of system silicon. And you won't comply with customer and industry requirements if you don't do complete "system" functional testing. With conventional test systems it means two of everything. Two testers, two test programs, two insertions, two data bases. And more than twice the time to get to market.

The A500 allows you to do it all with one system. So there's only one system to program. One insertion to make for both component and functional testing. And only one data base to work with. Which means significantly less time to market.

### **Vector Bus II™: the Great Integrator**

The heart of the A500 is Teradyne's unique Vector Bus II architecture. It integrates analog and digital VLSI test capability at the system level. Which means you won't have to build special applications hardware for every new device you design. Vector Bus II eliminates that costly custom-work bottleneck



## Why accept it in an Analog VLSI Test System?

with such features as TimeMaster™ Synchronization, Mixed-Signal Event Control, and MultiSource Data Mixing.

### A Picture's Worth a Thousand Keystrokes

The A500 also revolutionizes program development. Our IMAGE™ (Interactive Menu-Assisted Graphics Environment) software gives you graphics programming as powerful as device designers' CAD/CAE tools. Using a mouse to control multiple windows, pop-up menus and software "power tools," you move ideas rapidly from mind to screen. And much faster to market.

Teradyne's new A500 is the only test system with the features you need to win the race for Analog VLSI market opportunities. To find out more, call Beth Sulak at (617) 482-2700, ext. 2746. Or call your nearest Teradyne sales office or write: Teradyne, Inc., 321 Harrison Avenue, Boston, MA 02118.



**TERADYNE**  
*We measure quality.*

# VME/PLUS gives view of your

**H**old on to your seat. You're about to discover an entirely new level of VME performance. And life in the fast lane will never be the same.

Meet VME/PLUS. Our new family of VMEbus products with a host of sophisticated features

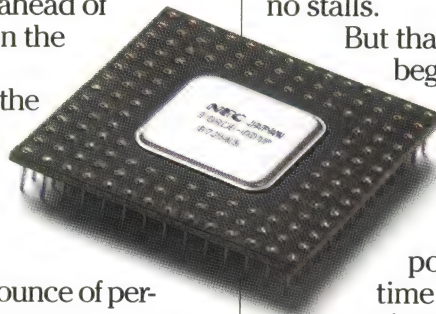
**VME/PLUS**

that will give your project the kind of performance you've only dreamed about.

VME/PLUS starts with a 68020 running at 25MHz without wait states. Complemented by 1MB of local memory. There's also a new VSB interface on P2. Which lets you add lots of local memory and I/O without increasing bus overhead. You also get two serial ports and up to 4MB of EPROM.

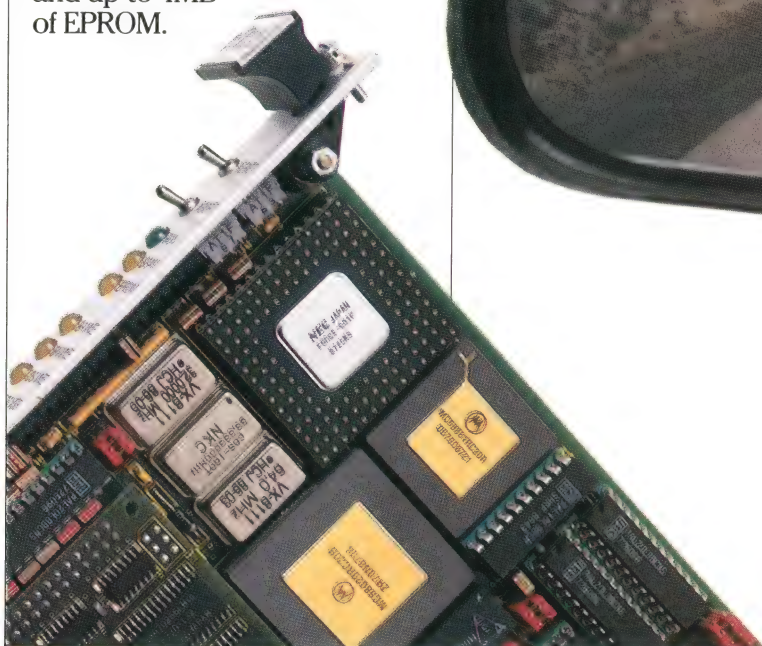
The result is system throughput that's way ahead of anything else in the VME world.

Think about the possibilities for real-time applications. For the first time, you can squeeze every ounce of performance from every processor.



With no wasted overhead. And no stalls.

But that's only the beginning. Take a look at the newest member of the VME/PLUS family, CPU 29. It comes with a powerful new real-time, multitasking monitor called VMEPROM™.



# you a different competition.

It's resident in EPROM, so there's no license required. And

no extra charge.

CPU-29 also incorporates a remarkable new gate array that packs

the functionality of many complex ICs into a single, 135-pin device.

What this new technology means for you is unprecedented levels of speed and system throughput, exceptional reliability and—here's the best part—lower total system cost.

And if that's not enough, we also offer a full set of off-the-shelf peripheral boards and software. All VMEbus

#### CPU-29 CHARACTERISTICS

PROCESSOR	68020/12.5 TO 25 MHz
CO-PROCESSOR	68882/12.5 TO 25 MHz
ZERO-WAIT-STATE	
SRAM	1MB
VMEPROM™	REAL-TIME, MULTITASKING MONITOR
EPROM	UP TO 4MB
SERIAL I/O	@ 1 WAIT STATE
SECONDARY BUS SUPPORT	2 RS-232 CHANNELS
	VSB

compatible. And guaranteed to cut the wait states out of your design cycle.

So if you're looking for the best way to stay ahead

of your competition and your deadline, take a close look at VME/PLUS. You'll get the best performance for simulation systems, real-time graphics, factory automation and many other tough applications.

Give us a call today for our new 500-page, 1988 data book. You'll get such a great view of VME performance, you'll never look back.

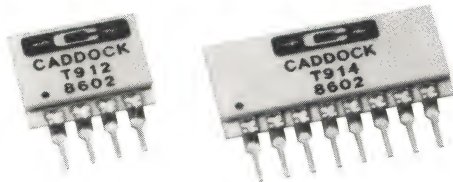
1(800)BEST VME.



FORCE COMPUTERS, INC.  
3165 Winchester Blvd., Campbell, CA 95008  
Telephone (408) 370-6300  
Telex 172465 Telefax (408) 374-1146

FORCE COMPUTERS, GmbH  
Daimlerstrasse 9 D-8012 Ottobrunn  
Telefon (089) 60091-0 Telex 524190 forc-d  
Telefax (089) 6 097793

# CADDOCK's Precision and Ultra-Precision Resistor Networks provide a designer's choice of performance that will optimize solutions in precision analog circuit designs.



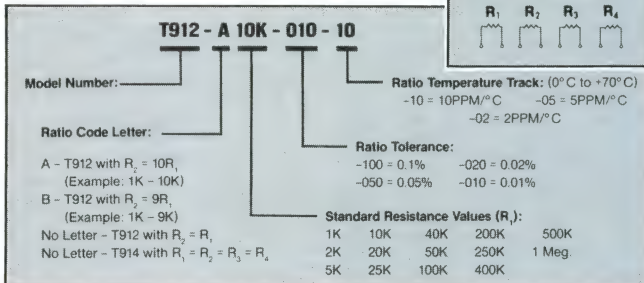
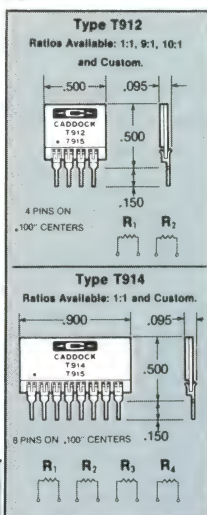
**Precision and Ultra-Precision Resistor 'Pairs' and 'Quads' deliver a selection of Ratio Tolerance to as tight as  $\pm 0.01\%$  and Ratio Temperature Coefficient to 2 PPM/ $^{\circ}\text{C}$  combined with exceptional long-term stability.**

## Standard Type T912 and T914 Precision and Ultra-Precision Resistor Networks.

Standard models of the Type T912/T914 Precision and Ultra-Precision Resistor Networks combine all of these performance characteristics:

- **Absolute Tolerance:** 0.1% for all resistors.
- **Ratio Tolerances:** 0.1%, 0.05%, 0.02% and 0.01%
- **Ratio Temperature Coefficients:** from 10 PPM/ $^{\circ}\text{C}$  to 2 PPM/ $^{\circ}\text{C}$ .
- **Absolute Temperature Coefficient:** 25 PPM/ $^{\circ}\text{C}$  from 0 $^{\circ}\text{C}$  to +70 $^{\circ}\text{C}$ .
- **Ratio Stability of Resistance at Full Load for 2000 Hours:** within 0.01%.
- **Shelf Life Stability of Ratio for Six Months:** within 0.005%.

The standard part number below provides a selection of over 500 in-production models of Type T912/T914 precision and ultra-precision 'pairs' and 'quads':

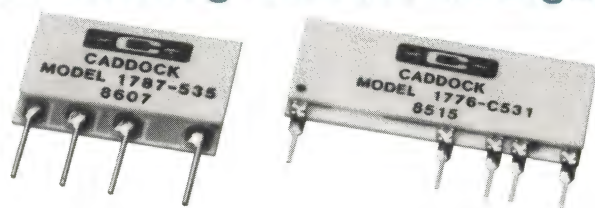
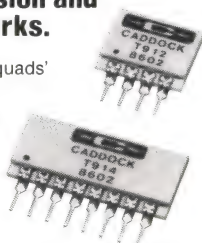


## Custom Type T912 and T914 Precision and Ultra-Precision Resistor Networks.

Custom models of these precision 'pairs' and 'quads' can include these special performance features:

- **Resistance Values:** from 1K to 2 Megohms with maximum ratios of 250-to-1.
- **Absolute TC:** as low as 15 PPM/ $^{\circ}\text{C}$ .
- **Ratio TC:** as low as 2 PPM/ $^{\circ}\text{C}$ .

• For Type T912/T914 data, circle Number 201.

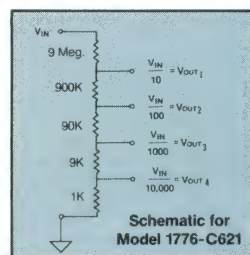


**Precision Decade Resistor Voltage Dividers and Current Shunt Resistor Networks deliver many optimum combinations of precision and temperature coefficient performance for high accuracy range-switching circuitry.**

## Standard Type 1776 Precision Decade Resistor Voltage Divider Networks.

The Type 1776 Precision Decade Resistor Voltage Dividers provide a family of networks that includes 3, 4 and 5-decade voltage dividers with ratios from 10:1 to 10,000:1. Standard performance includes a wide range of specifications in particular combinations that meet the most often requested requirements.

- **Absolute Tolerances:** from 0.25% to 0.1%.
- **Ratio Tolerances:** 0.25%, 0.1% or 0.05%.
- **Absolute TC:** from 50 PPM/ $^{\circ}\text{C}$  to 25 PPM/ $^{\circ}\text{C}$ .
- **Ratio TC:** from 50 PPM/ $^{\circ}\text{C}$  to 5 PPM/ $^{\circ}\text{C}$ .
- **Voltage Coefficient:** As low as 0.02 PPM/Volt.



With 36 standard models to choose from, each circuit designer can specify the exact levels of performance required by each application.

• For Type 1776 data, circle Number 202.

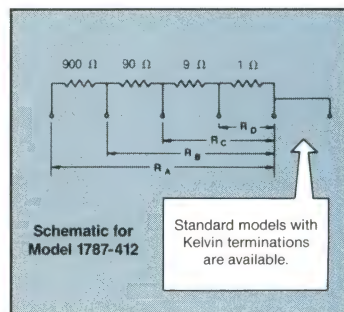
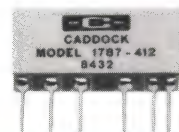
## Standard Type 1787 Precision Current Shunt Resistor Networks.

The Type 1787 Current Shunt Resistor Networks achieve the combination of performance requirements necessary to meet the demands of precision current measurement circuits, including laboratory and bench-type instrumentation:

- **Resistance Values:** 1 ohm, 10 ohms, 100 ohms and 1000 ohms.
- **Absolute Tolerances:** 0.25%, 0.1% or 0.05%.
- **Absolute TCs:** 100 PPM/ $^{\circ}\text{C}$ , 80 PPM/ $^{\circ}\text{C}$  or 50 PPM/ $^{\circ}\text{C}$ .

There are now 12 standard models of the Type 1787 Current Shunt Resistor Networks available for 3 and 4-decade applications, and prototype quantities of many models are normally available from factory stock.

• For Type 1787 data, circle Number 203.



Caddock's new 28-page General Catalog describes over 200 models of both standard and custom precision and ultra-precision resistors and resistor networks. For your personal copy, call or write our main offices at - Caddock Electronics, Inc., 1717 Chicago Avenue, Riverside, California 92507 • Phone (714) 788-1700 • TWX: 910-332-6108

# CADDOCK

HIGH PERFORMANCE FILM RESISTORS

# SIGNALS & NOISE

## Analog simulation tools

Several of our prospective customers asked that a circuit shown in EDN's May 14, 1987, Special Report (pg 138) on analog CAE be benchmarked as proof of the capability of Daisy's analog tools. According to David Shear, the article's author, all analog simulation tools would provide misleading results.

The circuit (pg 148) is a simple comparator, which, when breadboarded, exhibits instability in the form of oscillations around its switching threshold. The author correctly claims that most analog CAE systems would predict stable operation. However, the author's claim that the instability is due to the comparator's high source impedance and the lack of hysteresis is not strictly true.

In reality, all input signals and voltage rails are subject to noise. It's the noise that causes the device to oscillate when the input voltage reaches the required switching threshold, subject to the device's high input impedance, high open-loop gain, and consequent lack of hysteresis.

By introducing a noise source into the input waveform, you can reproduce the comparator's unstable operation. The accompanying Fig 1 depicts the schematic representation of the comparator circuit.

In Fig 2, the comparator output switches between positive and negative saturation when subjected to a noisy sawtooth input waveform; in other words, it's a "zero-crossing"

detector. On closer examination of the output, you see that the simulation successfully shows the many transitions expected around the threshold voltage.

This benchmark shows that an analog designer equipped with Daisy's analog CAE tools can successfully simulate a circuit to produce results comparable to those of a breadboard. It should be noted, however, that although analog CAE tools help the designer produce higher-quality designs, they don't replace engineering expertise. An inexperienced designer could produce misleading results with his simulation, but these tools will complement the skills and knowledge of an experienced designer.

*Dave Richards*

*Analog Applications Specialist  
Daisy Systems UK Ltd  
Basingstoke, UK*

*David Shear replies:*

*I don't believe that selectively placing noise into a circuit so that the results look like real-world results is the proper solution to the problem.*

*I would suggest that the addition of real-world parasitic capacitance that feeds the output back to the input would more closely match reality. Comparators have finite gain and wide bandwidth. When trying to resolve slow-moving inputs, they will, for a short time, be in a linear region. While they're in this linear region, if any of the output feeds back to the input (via the parasitic*

Fig 1

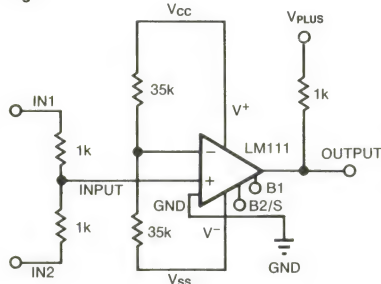
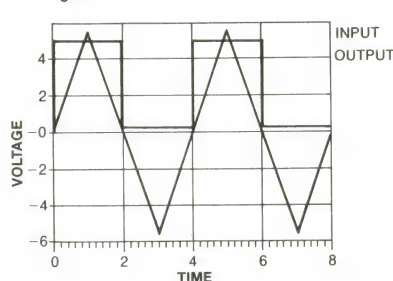
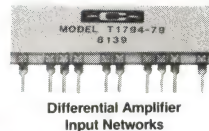


Fig 2



## Your Custom Precision and Ultra-Precision Resistor Networks from Caddock:

- Can be delivered in only 6 weeks ARO
- With total NRE charges typically under \$950<sup>00</sup>
- Includes 10 prototype networks for your in-circuit evaluation.
- Thin-Profile, Single-In-Line package design.



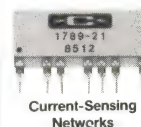
### Type T1794 Custom Low TC Precision and Ultra-Precision SIP Resistor Networks.

Caddock's Tetrinox® resistance films provide a wide choice of Absolute TCs, Ratio TCs and precision tolerance specifications. Select the performance of your custom network from the following:



- Resistance Values: from 500 ohms to 50 Megs.
- Absolute Tolerances: 1.0%, 0.50%, 0.25%, 0.20%, 0.10%, 0.05% and 0.025%.
- Ratio Tolerances: 1.0%, 0.50%, 0.25%, 0.20%, 0.10%, 0.05% and 0.025%.
- Absolute Temperature Coefficients: 50 PPM/°C, 25 PPM/°C and 15 PPM/°C from 0°C to +70°C.
- Ratio Temperature Coefficients: 50 PPM/°C, 25 PPM/°C, 10 PPM/°C and 5 PPM/°C from 0°C to +70°C.
- For Type T1794 information, circle Number 204.

### Type 1789 Custom Low Resistance Value Precision SIP Resistor Networks.



Using Caddock's Micronox® resistance films, your low resistance custom networks can now include:

- Resistance Values: from 0.5 ohms to 10,000 ohms.
- Absolute Tolerances: 1.0%, 0.50%, 0.25%, 0.20%, 0.10% and 0.05%.
- Ratio Tolerances: 1.0%, 0.50%, 0.25%, 0.20%, 0.10% and 0.05%.
- Absolute Temperature Coefficients: 100 PPM/°C, 80 PPM/°C and 50 PPM/°C from 0°C to +70°C.
- Ratio Temperature Coefficients: 80 PPM/°C, 50 PPM/°C, 25 PPM/°C and 15 PPM/°C from 0°C to +70°C.
- For Type 1789 information, circle Number 205.

Caddock's high thru-put manufacturing capabilities provide cost-effective, on-time delivery of your custom resistor network requirements. Custom network designs are now in-production in quantities from 500 networks per year to as high as 500,000 networks per year.

**For fast solutions to your custom resistor network needs, call our Applications Engineers at Telephone No. (714) 788-1700.**

**CADDOCK**  
HIGH PERFORMANCE FILM RESISTORS

File: Ferranti Semiconductors  
 Live: New product release  
 Report: SR25D...2.5V precision reference in SOT-23 package  
 Low knee current-ideal for battery powered applications  
 Low temperature coefficient  
 Initial VREF tolerances of 1, 2 and 3% available  
 Unconditionally stable-no requirement for external capacitor  
 Packaged in a standard SOT-23 surface mount package

UPDATE

## Update 4...2.5V SOT-23 bandgap ref.

Ferranti is extending its range of standard product ICs adding new voltage references, data converters, timers, motor speed controllers, telecom and SCSI devices among others.

Our philosophy is to provide system solutions at an economic cost. To achieve this, many of the products are designed to require little or no external circuitry.

However, sometimes the need for flexibility in system design requires a less dedicated approach. Ferranti also offers many of the sub-functions in monolithic form.

Ferranti is also very aware of the increasing demand for surface mounted packages, so most products are available

in SO and LCCs. But perhaps the best reason for buying from this product range is that Ferranti is committed to it.

To implement this commitment we have teams of design, application and marketing engineers whom you are welcome to consult and a wealth of data and application reports to make the design-in function that little bit easier.

Watch this space for the latest update.

IC Marketing  
 Ferranti Electronics Limited  
 Fields New Road Chadderton  
 Oldham OL9 8NP  
 Tel: 061-624 0515 Telex: 668038  
 Fax: 061-626 4946



**FERRANTI**  
 Semiconductors



### International Addresses:

- ☐ Ferranti GmbH, West Germany, Munich, Tel: (089)-3609-06-0 ☐ Ferranti Electronics Benelux, Antwerp, Tel: (0)-3/540.49.20
- ☐ Ferranti Electronics Sweden, Stockholm, Tel: (08)-52 07 20 ☐ Ferranti Computer Systems (Australia) Pty Limited, Revesby, Tel: (02)-708 6655
- ☐ Ferranti Interdesign Inc. USA, California, Tel: (408)-438-2900.

## SIGNALS & NOISE

capacitance), oscillations will usually occur. Lowering the source resistance or using hysteresis often solves the problem.

However, the reason the comparator oscillated is not the issue. The point I was making is that the model did not predict the circuit's true operation. After building the prototype, we found a discrepancy. The model was in error. Now we are arguing about how to fix the model. Who is right? Again that is not the point.

### Article neglected the IBM RT PC

I found the Special Report on workstations in the October 29, 1987, issue of EDN (pg 168) to be quite readable and generally accurate. However, I feel there is a serious omission in the list of systems shown in Table 1 (pg 172).

Noticeable by its absence is the IBM RT PC. The RT PC's price is in the range shown, the processor is a RISC (reduced-instruction-set computer) chip developed by IBM, and the feature list certainly places the RT PC in the race.

Most impressively, however, we have found in our benchmarking that the current version of the RT PC has performance superior to most of the systems in the chart. The RT PC has performance that is generally superior to the fastest of the Motorola-based systems (25-MHz 68020 machines). The current RT PC really is a superior system that has received less notice than it deserves.

David Wilson

Workstation Laboratories  
Humboldt, AZ

### WRITE IN

Send your letters to the Signals and Noise Editor, 275 Washington St, Newton MA 02158. We welcome all comments, pro or con. All letters must be signed, but we will withhold your name upon request. We reserve the right to edit letters for space and clarity.

## SWITCH MODE POWER FIT FOR YOUR NEEDS

### Case 21

750 Watts

5"x6.5"x10

Single Outputs  
Up to 5V 150A

15A Auxiliary Mag  
Amp Outputs

The power and flexibility you'd expect from 5X8X11 "slot" switching power supplies is now available with room to spare with the Qualidyne Case 21. Delivering 750 Watts from 1 to 7 fully regulated outputs. A unique package design that makes system connections a snap. A full assortment of standard features and options plus safety approvals and compliance with worldwide standards. Cut your power supply down to size with the Qualidyne Case 21.



THE SWITCHER FIT FOR YOUR NEEDS

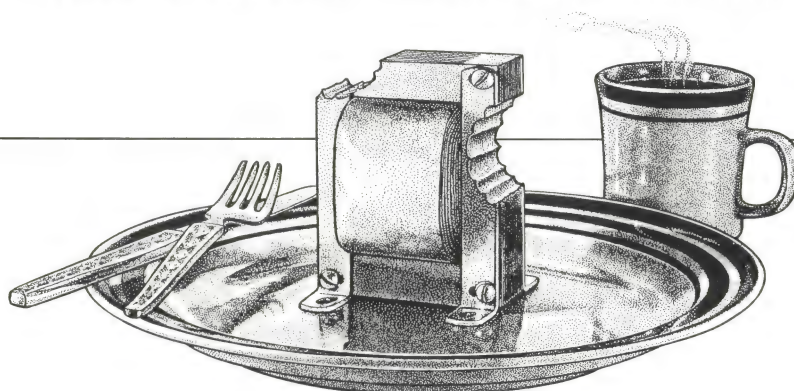
**Qualidyne**

Qualidyne Systems, Inc.

3055 Del Sol Boulevard, San Diego, CA 92154  
(619) 575-1100 Telex: 709 029 FAX: 619 429 1011  
(800) 445-0425 In Calif. (800) 237-6885

CIRCLE NO 2

## We eat conventional transformers for breakfast



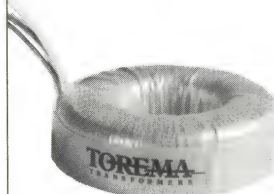
With our advanced toroidal transformers, we offer a veritable menu of benefits for your state-of-the-art electrical designs and applications.

Our TOREMA toroids are lighter, quieter and smaller than traditional laminated transformers AND other toroids, too... food for thought when you're looking for exceptional technical and design advantages as well as significant savings in your finished product.

Contact us for more information on TOREMA toroidal transformers—we'll feed it to you in a hurry.

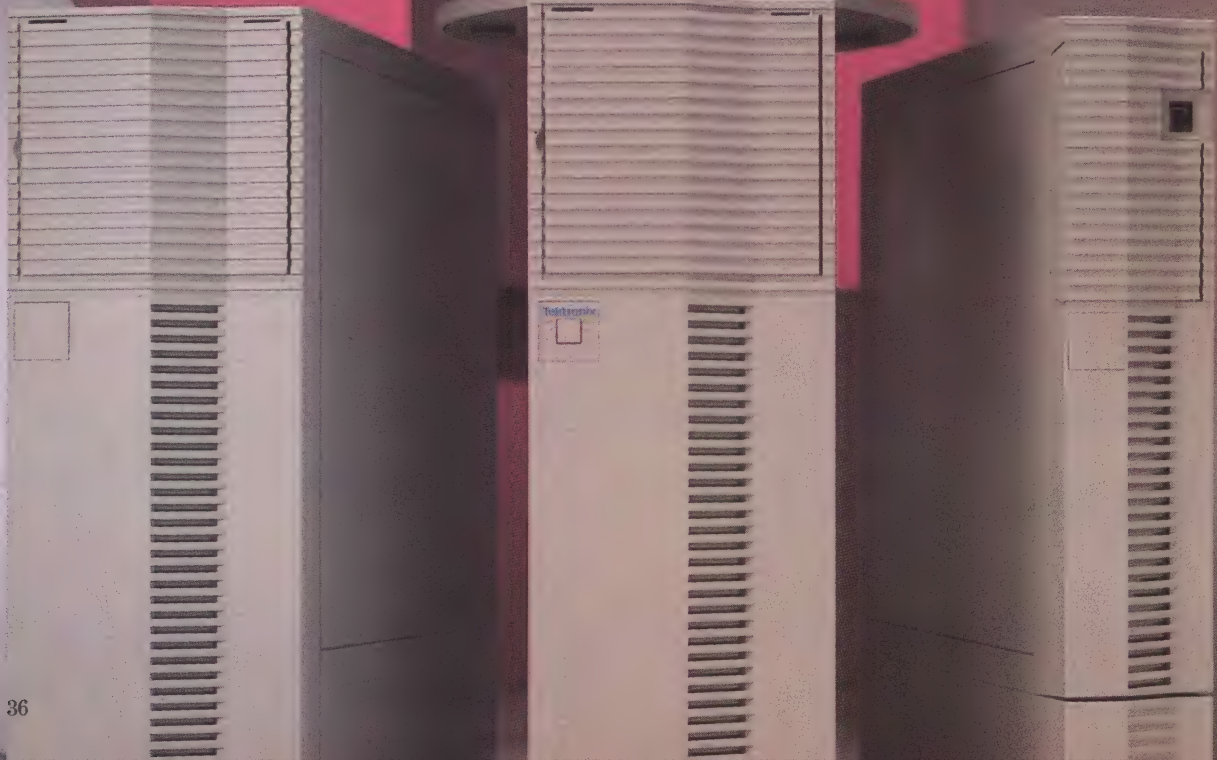
**TOREMA**  
TRANSFORMERS

Torema U.S.A., Inc.  
6699 Portwest Dr. / 130  
Houston TX 77024  
(713) 861-6643



**TEK UNIX-BASED WORKSTATIONS**

**THE ONLY LINE OF  
GRAPHICS WORKSTATIONS  
DESIGNED AS IF THERE  
IS A TOMORROW.**





**Finally there are graphics workstations as committed to incorporating industry standards and to ensuring upgradability, as to breaking today's graphics throughput barriers.** You know that barriers are made to be broken. But that your investment in hardware and software, in systems and training, is made to last.

That's why Tek's new 4300 Series Workstations are designed with parallel graphics and compute processors. This architecture gives you the choice of putting Tek graphics to work in a workstation or terminal configuration. And because you can later upgrade that terminal to a fully integrated workstation, you know your investment in Tektronix

engineering has lasting value.

Just as forward-looking is the fact that the 4300 Series includes the industry's most established standards: UNIX, 68020 processors, Ethernet, TCP/IP, X Windows, and Tek PLOT 10® software, enhanced to complement the high throughput of these new systems.

With 14 different configurations, a common user interface, Tek's de facto graphics standard, and unsurpassed quality, the 4300 Series allows not just leading performance until the next breakthrough comes along—but growth for tomorrow.

For more information on the 4300 Series, contact your local Tek representative today.

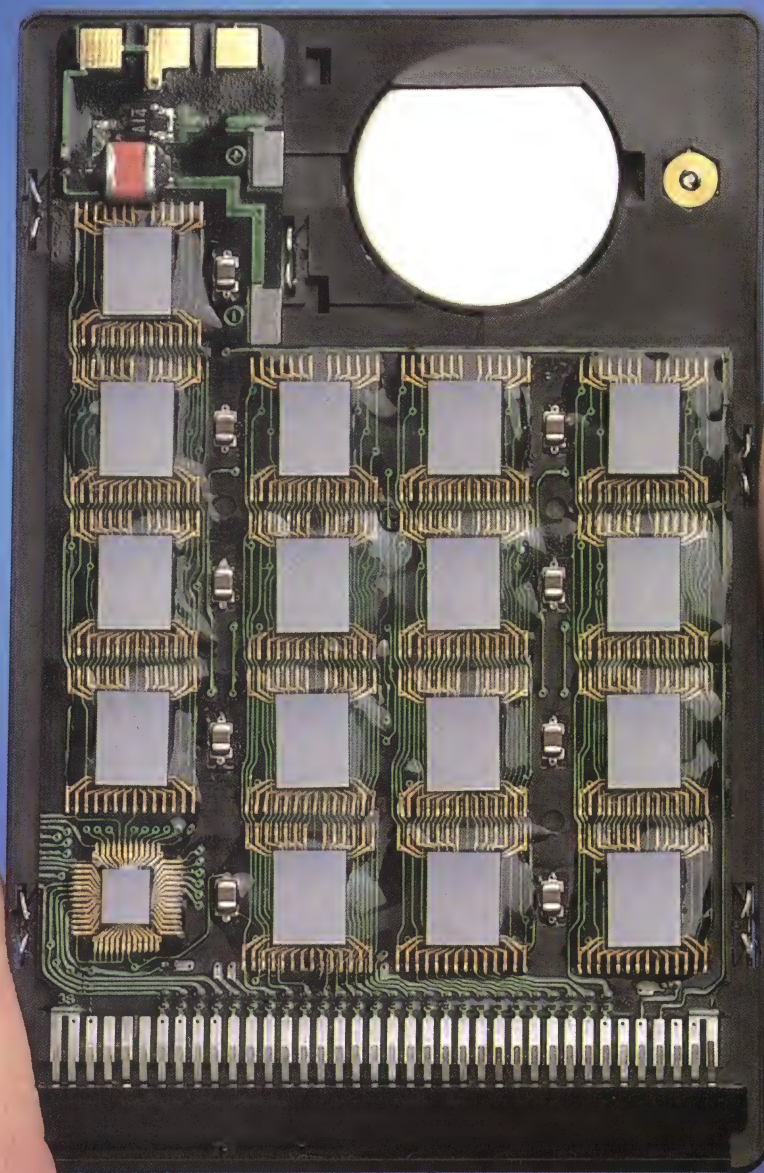
**Or call 1-800-225-5434.**

In Oregon, 1-235-7202.

**CIRCLE NO 38**

Copyright ©1987, Tektronix, Inc. All rights reserved. AHT-107  
Graphics courtesy of: Imagen/Paris using DALIM,  
PLOT 10® TekniCAD, ESRI, SDRC/CAE, and MCS.

**Tektronix**  
COMMITTED TO EXCELLENCE



---

## How to improve your memory.

### Get 1 Mbit of RAM in a credit-card size cassette.

The DuPont Memory Cassette System is the first system of its size to deliver up to 1 Mbit of memory. It gives you everything you can ask for—size, speed, and security.

While other types of data storage media may have slightly more memory, you can fit multiple DuPont Memory Cassettes in the space of conventional drive systems. These cassettes can provide greater memory and direct access to your data. And they're faster too—about  $10^7$  times faster, in fact.

Unlike floppy disks, the cassette protects closed architectures and virtually eliminates copying.

With a long-life replaceable lithium battery, to avoid erasure during power failures. And the cassette is designed to offer protection from electromagnetic interference and electrostatic discharge.

We've put all those features in a really tough package—the connector is rated for 10,000 mating cycles minimum; tested up to 50,000 cycles—to create a truly unforgettable system. Perfect for your every application, RAM or ROM. The Memory Cassette System will allow you to save on components, save on space, and still design a more versatile product.

We'll be glad to tell you more. Just call 1-800-527-2601, for our free brochure. But call now, while it's fresh in your memory.



---

**DuPont Electronics**  
Share the power of our resources.



REG. U.S. PAT. & TM. OFF.  
CIRCLE NO 37

# The SPACE SAVER.

## The Model 615 Trackball

No room for a trackball in your new console design? Then our Model 615 will convince you there's plenty of room for improvement.

Only 1.5 inches in diameter in a 2.75 x 2.75 inch case, the Model 615 needs only 1 inch of back panel space. Even so, it provides the high quality and good feel you'd expect only from a much larger trackball.

And we've left plenty of room for options. You can get the Model 615 with a quadrature square wave or TTL level pulse output. Coded digital outputs are also available in a slightly larger case.

Call or write us for more information. And we'll prove all this room is no rumor.



**Measurement Systems, Inc.**

121 Water Street, Norwalk, CT 06854, U.S.A. (203) 838-5561

CIRCLE NO 4

# NEW!

**ThermaPro-V  
Technology  
for the  
Major DC and  
Patriot DC fans.**



Introducing Major DC and Patriot DC with optional ThermaPro-V Technology. High pressure capabilities for computer and telecommunications applications, combined with ThermaPro-V, make Major DC and Patriot DC a design engineer's answer to complex cooling problems.

Comair Rotron's Major DC and Patriot DC with patented feathered edge blades offer wide voltage input and extended performance ranges. Simplified circuits, increased options, quiet ball bearing operation and an all metal venturi are now available in a single fan for multiple use.

ThermaPro-V Technology, Voltage Regulated, Programmable, and Thermally Speed Controlled.

Comair Rotron. The First Name in Forced Convection Cooling Technology.

**Therma  
Pro-V**  
FORCED CONVECTION  
COOLING TECHNOLOGY

For literature only call 800-367-2662. In NYS  
and for product or technical assistance call our  
application Engineering Dept. at (914) 246-3615.

# COMAIR ROTRON

a KLI company

12 North Street Sawyer Industrial Park, Saugerties, N.Y. 12477-1096  
Telephone: (914) 246-3615 TWX 910-333-7572 Telex: 551496

CIRCLE NO 5

## CALENDAR

**Third Annual Technical Symposium on Optoelectronics and Laser Applications in Science and Engineering**, Los Angeles, CA. SPIE, Box 10, Bellingham, WA 98227. (206) 676-3290. January 10.

**ATE and Instrumentation Conference West**, Anaheim, CA. MG Expositions Group, 1050 Commonwealth Ave, Boston, MA 02215. (800) 223-7126. January 12 to 14.

**Third Annual Battery Conference on Applications and Advances**, Long Beach, CA. Cecile Duong, Department of Electrical Engineering, California State University at Long Beach, 1250 Bellflower Blvd, Long Beach, CA 90840. (213) 498-4605. January 12 to 14.

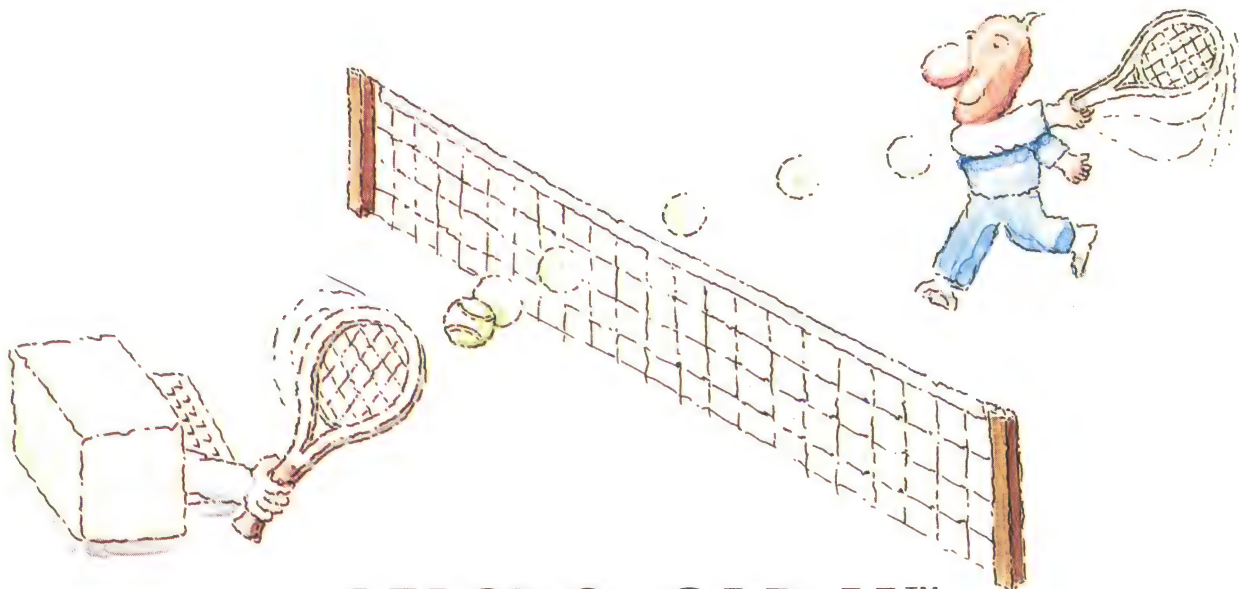
**Designing Real-Time Hardware for Digital Signal Processing** (short course), Los Angeles, CA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. January 12 to 15.

**Real-Time Operating Systems** (short course), San Diego, CA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. January 12 to 15.

**Annual IEEE Design Automation Workshop**, Apache Junction, AZ. Walling Cyre, Control Data, HQM 173, Box 1249, Minneapolis, MN 55440. (612) 853-2692. January 13 to 15.

**Conference on Optical Fiber Communication (OFC '88)**, New Orleans, LA. Optical Society of America, 1816 Jefferson Pl NW, Washington, DC 20036. (202) 223-0926. January 25 to 27.

**Neural Networks for Artificial Intelligence**, Los Angeles, CA. Technology Transfer Institute, 741 10th St, Santa Monica, CA 90402. (213) 394-8305. January 25 to 27.

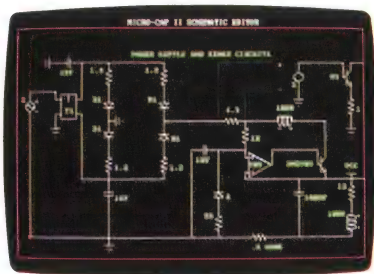


# MICRO-CAP II.™

## The CAE tool with fully interactive analog simulation for your PC.

Spectrum Software's MICRO-CAP II® is fast, powerful, and feature rich. This fully interactive, advanced electronic circuit analysis program helps engineers speed through analog problems right at their own PCs.

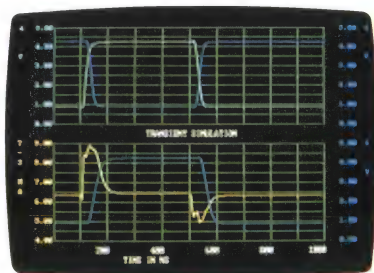
MICRO-CAP II, which is based on our original MICRO-CAP software, is a field-proven, second-generation program. But it's dramatically improved.



*Schematic Editor*

MICRO-CAP II has faster analysis routines. Better resolution and color. Larger libraries. All add up to a powerful, cost-effective CAE tool for your PC.

The program has a sophisticated integrated schematic editor with a pan capability. Just sketch and analyze. You can step



*Transient Analysis*

component values, and run worst-case scenarios—all interactively. And a 500-type\* library of standard parts is at your fingertips for added flexibility.

MICRO-CAP II is available for IBM® PCs and Macintosh.™ The IBM version is CGA, EGA, and Hercules® compatible and costs only \$895 complete. An evaluation version is available for \$100. Call or write today for our free brochure and demo disk. We'd like to tell you more about analog solutions in the fast lane.

- Integrated schematic editor
- Fast analysis routines
- High-resolution graphic output
- Standard parts library of 500\* types

\*IBM versions only.

- Transient, AC, DC, and FFT routines
- Op-amp and switch models
- Spec-sheet-to-model converter\*
- Printer and plotter\* hard copy



*AC Analysis*

**spectrum**

1021 S. Wolfe Road, Dept. E  
Sunnyvale, CA 94087  
(408) 738-4387

MICRO-CAP II is a registered trademark of Spectrum Software.

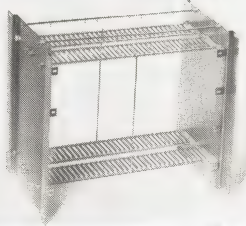
Macintosh is a trademark of McIntosh Laboratory, Inc. and is being used with express permission of its owner.

Hercules is a registered trademark of Hercules Computer Technology

IBM is a registered trademark of International Business Machines, Inc.

CIRCLE NO 36

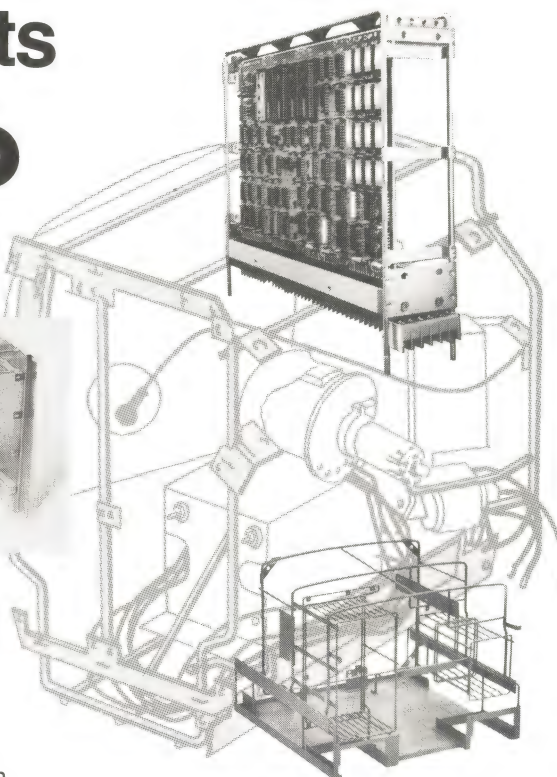
# Cut Costs 50% on Electronic Chassis and Enclosures



Use Steel Wire  
construction . . .  
one source does it all

- R & D
- prototyping
- in-house tooling
- short runs
- low- or high-vol. production
- in-house finishing
- defect-free performance
- just-in-time delivery

Send for FREE Design Guide



**TITCHENER** E.H. Titchener & Co.  
28 Titchener Place  
P.O. Box 1706  
Binghamton, NY 13902  
Phone 607-772-1161  
FAX 607-771-0264

CIRCLE NO 6

## IF YOU'RE USING PLASMA DISPLAYS, WHY NOT CONSIDER A RESOURCE INSTEAD OF A SUPPLIER?

Who are you buying from . . . a company that fills orders? Or one that literally puts their entire facility at your disposal?

Telegenix wants to be your resource for DC plasma displays. But we intend to earn and keep your business by taking the time to know your exact needs, and using our extensive engineering and manufacturing capabilities to produce the displays you

require. If our off-the-shelf line doesn't provide pin-to-pin compatibility, rest assured, we will custom engineer our products to meet any specifications and back them with a two year warranty. All of this, we might add, at very competitive pricing.

If this isn't what you're hearing from your present source, perhaps you need the *resource* in plasma displays . . . Telegenix!

### TELEGENIX®

AN INDUCTOTHERM COMPANY

26 Olney Avenue, P.O. Box 5550, Cherry Hill, NJ 08034 • (800) 424-5220 (EXT. 132)  
in NJ call (609) 424-5220 (EXT. 132)

CIRCLE NO 7

## CALENDAR

**Annual Reliability and Maintainability Symposium**, Los Angeles, CA. V R Monshaw, RCA, Astro Electronics, Box 800, MS 55, Princeton, NJ 08540. (609) 426-2182. January 26 to 28.

**Designing Real-Time Hardware for Digital Signal Processing** (short course), Montreal, Canada. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. January 26 to 29.

**High-Performance Computer Architectures** (short course), Washington, DC. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. January 26 to 29.

**APEC '88**, New Orleans, LA. IEEE Power Electronics Council, 655 15th St, NW, Suite 300, Washington, DC 20005. (202) 639-4990. February 1 to 5.

**Microwave Circuit Design I** (short course), El Segundo, CA. UCLA Extension, 10995 Le Conte Ave, Los Angeles, CA 90024. (213) 825-3344. February 1 to 5.

**High-Performance Computer Architectures** (short course), Los Angeles, CA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. February 2 to 5.

**Microwave Circuit Design II** (short course), Los Angeles, CA. UCLA Extension, 10995 Le Conte Ave, Los Angeles, CA 90024. (213) 825-3344. February 8 to 12.

**Unix Technical Conference**, Dallas, TX. Usenix Conference Office, Box 385, Sunset Beach, CA 90742. (213) 592-1381. February 9 to 12.

**ULTEM®**  
POLYETHERIMIDE  
RESIN

**LR™**  
THERMOPLASTIC  
ELASTOMER

**XENOY®**  
THERMOPLASTIC  
ALLOY

**GELOY®**  
ENGINEERING  
THERMOPLASTIC

**LOMOD®**  
ENGINEERING  
ELASTOMER

**NORYL  
GTX™**  
ENGINEERING  
THERMOPLASTIC

**VALOX®**  
ENGINEERING  
THERMOPLASTIC

**EXAN®**  
POLYCARBONATE  
RESIN

**NORYL®**  
MODIFIED RPO  
RESIN



# GE Plastics

## Product Genetics.

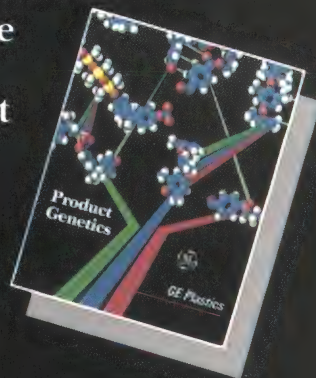
Progressive generations of superior materials: copolymers, alloys, composites. Selectively bred to perform.

The GE family tree. Breadth and depth of product technology, creating opportunities for ultimate design and performance.

The basic building blocks of innovation: materials excellence enhanced by a unique matrix of program development resources—only from GE.

For a performance profile of the leading family in engineering plastics, request our free Product Genetics Brochure today:

**(800) 845-0600.**



CIRCLE NO 35

® Registered Trademarks, ™ Trademarks of General Electric Company.

# The one interconnect system

Thermoset rectangular connectors with 104 and 152 contact positions.

Pre-assembled thermoset MSM HYFEN™ rectangulars in 9 size (9-75 positions).

Reliable, low cost Thermoplastic QIKMATE™ plugs and receptacles in 10 sizes (2-36 contact positions).

BANTAM™ MIL-style at commercial prices with fixed thermoset inserts (4-48 positions).

# you never outgrow!

## Trim Trio™

**Single contact system satisfies over 100,000 interconnect variations.**

Designed for maximum flexibility, proven in millions of applications—Burndy's TRIM-TRIO contact/connector family lets you meet all your application needs—no matter how often they change—without changing your contact system! Your tooling! Or your installation procedures!

You simply select the contact/housing combination that best satisfies your current needs. Then, as needs change, you just change the combinations. Nothing else! Not your tooling! Not your operations. Nothing! And no matter what combination you choose—or how many—you still enjoy all the advantages of standardization. Which means faster, more economical assembly and greater quality control—all along the line.

So make it easy on yourself. Standardize on the proven reliability of the Burndy TRIM-TRIO interconnect system. The one system that offers you thousands of

variations. The one system you'll never outgrow. And to make things easier, all variations of the TRIM-TRIO family are available—off the shelf—at your local Burndy Distributor. For details, write: Burndy Corporation, TRIM-TRIO Product Manager, Norwalk, CT 06856. Or call: 203-852-8711.

### THE TRIM-TRIO CONTACTS SYSTEM:

**Closed barrel Machined Contacts** for both crimp and wire-wrap power applications up to 13 amps. **Open barrel Precision Formed** contacts for power and signal applications. **Sub-miniature Coax** (one-piece or 2-piece) for coaxial cable, shielded conductors and twisted pairs. These three basic types (with variations for different conductors, contact platings and termination options) make up the TRIM-TRIO contact system. All can be intermixed in any of scores of Burndy connector housings designed around this contact system.



Offices in principal cities throughout the United States.

Versatile, quick disconnect cable splice.

**METALOK™ THERMOPLASTIC CIRCULAR SERIES:** with rugged metal bayonet coupling. 9 sizes (4 thru 48 positions).

**BANTAMATE II™** low cost circulars—deliver up to 500 mating cycles. Positive polarization. Quick disconnect. 4 sizes (4 thru 30 positions).

CIRCLE NO 34

# HOW TO END THE OPTICAL ILLUSION.

People have been talking about optical drives for years. But have you ever actually seen one work?

Well, now you can.

Because while others were talking about optical drives and solutions, Maxtor was developing them. And now we're shipping our 800MB 5¼-inch optical WORM drive in volume.

It's the first in our family of optical drives. And it's perfect for high-volume back-up, image or archival storage.

It's offered with a full complement of integration software and hardware, including media, cable and host adapter. Or it's available as a fully-configured plug-and-play mass storage subsystem.

Either way, it's fully compatible with most popular computers.

So don't wait to make optical drives a reality for your system.

Contact the Maxtor distributor or sales office listed below for complete technical and ordering information.

Because seeing is believing.



## Maxtor

Sales offices: Atlanta (404) 455-4226, Austin (512) 345-2742, Boston (617) 872-8556, New Jersey (201) 747-7337, Orange County (714) 472-2344, San Jose (408) 435-7884, Woking, England (44)/4862-29814, Tokyo, Japan 81-3-431-8940.

Distributed by Anthem Electronics, (714) 768-4444, (408) 295-4200, (617) 657-5170, Future Electronics, (514) 694-7710, Pioneer Standard Electronics, Inc., (216) 587-3600, (301) 921-0660, Quality Components, Inc., (214) 733-4300, Storex Corporation, (617) 769-3400, Storage Dimensions, Inc., (408) 395-2688.

© 1987 Maxtor Corporation

CIRCLE NO 33

# EDITORIAL

## Standards aren't always standard



I'm glad my local hardware store stocks standard hardware. If manufacturers developed their own fittings, nuts, and bolts, mechanical repairs and projects would be impossible. The same is true in electronics. Standard component values and packages make designing circuits easier. However, as electronic systems become more complex, standards become less standard, which leads to trouble.

In the early days of microcomputers, the S-100 Bus became a de facto standard. However, that standard meant different things to different suppliers. Undefined bus signals and timing relationships often led to chaos as suppliers defined signals to meet their own needs. Users could spend days debugging a system after simply exchanging one CPU board for another. The IEEE finally standardized the S-100 Bus specification—just when the bus's popularity plummeted.

Even the availability of an industry-wide standard doesn't guarantee compatibility. Anyone who has connected RS-232C-based devices can attest to the standard's transformation into an ever-present nightmare. Almost everyone has his own interpretation of what RS-232C signals do.

More-complex standards lead to more-complex problems. For example, even on the fairly simple STD Bus, you can't always exchange one CPU card for another. Cards compatible with a 68000-based CPU board may not work with a Z80-based CPU card. Even the well-thought-out VME Bus has its problems. Why else would there be interest in setting up laboratories to test VME Bus products?

Software has its own set of problems. Although the Basic and C languages are fairly standard, there are enhancements and extensions galore. Such additions may make it difficult for users to make their individual versions compatible with future language standards. Even among so-called "MS-DOS-compatible" PCs, software-compatibility problems persist. Programs that run on one computer may not run on another.

The problem of standardization hasn't spared the automotive sector, either. Although General Motors established the Manufacturing Automation Protocol (MAP) standard, it has already made major revisions. MAP users may be comforted to know that the MAP Group Steering Committee says that there will be no major change in the standard for six years. However, the committee envisions "minor" changes, so although you won't see version 4 soon, you may find version 3.1 or 3.2 around the corner.

In sum, although standards are useful and good for the electronics industry, it's wise to use caution when adopting them and remember that they're only a starting point.



Jon Titus  
Editor

# High-resolution conversion



# in the blink of an eye.

## Get video speed, low power consumption, high resolution and superior price/performance with our new CMOS data converters.



We've expanded our line to include more CMOS flash ADC's, a charge balancing ADC, an SPI ADC and a DAC. All featuring single 5V supply operation.

We also offer a new high-speed op amp especially well-suited to driving ADC's or video cables.

### 4, 6 and 8-bit CMOS flash ADC's.

Choose from 4, 6 and 8-bit ADC's. All operate at video speeds, with clocking speed and input bandwidth specified at 5V. What makes these flash ADC's special is silicon-on-sapphire construction, resulting in low cost, high speed, very low input capacitance, low power consumption and inherent latch-up resistance.

### 10-bit CMOS charge balancing ADC.

This 10-bit successive approximation ADC captures fast moving signals, providing excellent resolution.

It features a built-in fast track and hold, with conversion rates of 150 KHz and an input bandwidth of 1.5 MHz. Even at the maximum rate, power consumption is less than 20 mW.

### 10-bit CMOS serial ADC.

The CDP68HC68A2 is selectable for either 8- or 10-bit resolution and has an 8-channel multiplexer allowing up to 8 channels of inputs. The device can be used directly with our CDP68HC05C4, C8 or D2 microprocessors or other similar SPI (Serial Peripheral Interface) buses.

### 8-bit CMOS R-2R video-speed DAC's.

These CMOS/SOS digital-to-analog converters operate

from a single 5V supply at video speeds and can produce "rail-to-rail" output swings. Typical update rate is 50 MHz. Settling is fast (20 ns typical) to 1/2 LSB. "Glitch" energy is minimized by segmenting and bar graph decoding of upper 3 bits.

### High-speed op amp.

Specially designed for use with data converters, the CA3450 op amp has excellent speed and transmission line driving capabilities.

For 10-bit accuracy, it settles to within 1/2 LSB in 40 ns with a 2V input signal. And it can drive up to four 50 ohm transmission lines.

ADC's	Res. Bits	Conv. Rate Hz	Power Diss. (mW)	Pkg. Leads	1K Price
CA3304E	4	20M	30	16	2.95
CA3304AE	4	25M	35	16	4.50
CA3306CE	6	10M	65	18	5.50
CA3306E/3306AE	6	15M	70	18	6.25/11.25
CA3318E/3318CE	8	15M	150	24	38.50/24.00
CA3310E/3310AE	10	150K	15	24	6.00/8.00
CDP68HC68A2E	10	10K	15	16	3.75
DAC's					
CA3338E/3338AE	8	50M	100	16	6.00/8.40
OP AMP	UGBW Hz	Slew Rate (X10)	I <sub>out</sub> MA	Pkg Leads	1K Price
CA3450E	200M	300V/μSec	±75	16	2.70

### Data in a flash.

For data sheets of these new products, call toll-free 800-443-7364, extension 19. Or contact your local GE Solid State sales office or distributor.

In Europe, call: Brussels, (2) 246-21-11; Paris, (1) 39-46-57-99; London, 0276-685911; Milano, (2) 82-291; Munich, (89) 63813-0.



GE Solid State

### GE/RCA/Intersil Semiconductors

These three leading brands are now one leading-edge company. Together, we have the resources—and the commitment—to help you conquer new worlds.

## New hermetically sealed surface mount thermistor!



Available in bulk or tape and reel for automatic surface mounting.

The all new SMS™ (surface mount sensor) series thermistors offer fast response, high interchangeability and long term stability, making them ideal for both temperature sensing and compensation. Hermetic design makes the SMS™ series more durable and resistant to cleaning materials. The availability of a wide range of resistance values and slopes allows more flexibility in designing with surface mount applications.

Shown actual size

Phone or write for your free design data.

**MIDWEST COMPONENTS INC.**

P.O. Box 787  
1981 Port City Boulevard  
Muskegon, MI 49443  
(616) 777-2602  
TWX: 510-394-4130

# EDN INFO CARDS

The Fastest, Most Cost-Effective Way to Generate Sales Leads!

**THERMISTOR SENSOR**

NEW! **1,590\***

**NO MORE BLOWN FUSES!**

**1,606\***

Introducing our new Self-restoring Polymer...

Port City Industrial Park  
Box 787  
Muskegon, MI 49443  
616-777-2602

**Step into the future with SynchroStep.**

**594\***

I WANT TO SEE THE FUTURE OF TECHNOLOGY.

**RUSH ME YOUR FULL COLOR 6 PAGE BROCHURE.**

Name \_\_\_\_\_  
Title \_\_\_\_\_  
Company \_\_\_\_\_  
Address \_\_\_\_\_  
City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_

**Today's best sourcebook on optoelectronic components is yours... FREE!**

**2,337\***

From IREDS to reflective assemblies. Military devices to slotted switches. The comprehensive 400-page Optoelectronic Sourcebook has it all. And it's yours, free, if you fill out this card and mail it today. It will make your TRW quality built into each component. Fill out this card and mail now for your free optoelectronic sourcebook.

Name \_\_\_\_\_ Title \_\_\_\_\_

**DISK-LESS PC SYSTEMS MADE EASY**

Fastore's SolidISK™ and SolidISK/LI™ Solid-state, non-volatile read-write memory systems for IBM PC's and compatibles.

SolidISK - EPROM's have never been this easy!

- 192KB 788KB of read-only storage
- Onboard EPROM programmer
- Complete Hardware & Software Support

SolidISK/LI - The best of both worlds.

- Non-volatile, read-write system
- 384KB to 4096KB and 96KB
- 4 Year Data Retention with battery

Please send info on: ☐ SolidISK ☐ SolidISK/LI Please Call Me

Name \_\_\_\_\_ Title \_\_\_\_\_  
Company \_\_\_\_\_  
Address \_\_\_\_\_  
City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_  
Phone \_\_\_\_\_

**FASTORE**  
203-834-1975

Send me the new Thermalloy

**EAT SINK CATALOG**

- Stamped and extruded heat sinks
- Die cast, precision and pulsed
- Mounting pads and shoulder washers
- Power sockets
- Printed circuit board assemblies
- Thermal paste and thermal grease
- Thermal interface materials
- Thermal management solutions

**1,004\***

Name \_\_\_\_\_ Title \_\_\_\_\_  
Company \_\_\_\_\_  
Address \_\_\_\_\_  
City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_  
Phone \_\_\_\_\_

With EDN Info Cards, you can turn a small investment into high-quality sales leads.

Issued six times per year in loose-deck packs, EDN Info Cards are delivered to EDN magazine's U.S. circulation of 121,500 specifiers and buyers. Which means they deliver results! In fact, the average card in a deck pulls literally hundreds of prospects.

You'll enjoy this steady, dependable source of qualified leads for less than 1½¢ per name. And because all inquiries come directly back to you, the faster you respond, the faster you get results.

Used as an adjunct to an advertising/promotion campaign or all by themselves, EDN Info Cards will generate the qualified leads you need to sell your products.

For further information, contact Lauren Fox, EDN Info Cards Manager, at (203) 328-2580.

\* Numbers represent actual responses.

# SEE IF YOU KNOW A GOOD AD WHEN YOU SEE IT *and win a camcorder!*

EDN magazine wants your opinion. Simply tell us which three advertisements in this issue of EDN did the best job of combining superior design with well-written copy to catch your interest and provide useful information.



We will then submit your name in a random drawing to win a CAMCORDER. That's a value of nearly \$1500. And that's not all.

You could also be one of ten lucky winners of \$25 gift certificates to Radio Shack. Send in your entry card today!

[Tear along dotted line]

**Yes, I know a good ad when I see it. Here are my three favorites from this issue of EDN:**

1. Company \_\_\_\_\_ Page No. \_\_\_\_\_

Comment \_\_\_\_\_

2. Company \_\_\_\_\_ Page No. \_\_\_\_\_

Comment \_\_\_\_\_

3. Company \_\_\_\_\_ Page No. \_\_\_\_\_

Comment \_\_\_\_\_

Note: If you vote for an insert in this issue, please indicate it as such.

Name \_\_\_\_\_ Date \_\_\_\_\_

Title \_\_\_\_\_

Company \_\_\_\_\_

Address \_\_\_\_\_

City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_

Phone \_\_\_\_\_

# CONTEST RULES

1. List your top selections on the entry card provided. Be sure to indicate the name of the advertiser (company or organization) and the page number. If the chosen ad is an insert, please indicate it as such. Ads placed by Cahners Publishing Company cannot be considered in this contest.
2. No more than one entry may be submitted by any one individual. Entry cards must be filled in completely, or they will not be considered.
3. To qualify, you must be an electronic design engineer or engineering manager, engaged in electronic design engineering, or involved in setting standards for design components and materials.
4. Contest void where prohibited or taxed by law. Liability for any taxes on prizes is the sole responsibility of the winner. Employees of Cahners Publishing Company are not eligible for participation.
5. Entry cards must be postmarked by February 18, 1988.
6. Winners will be picked in a random drawing. Decisions of the contest judges will be final.

[Tear along dotted line]



NO POSTAGE  
NECESSARY  
IF MAILED  
IN THE  
UNITED STATES

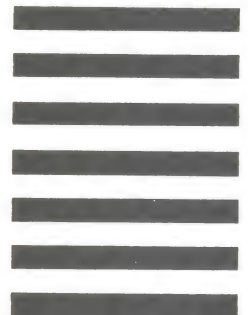
## BUSINESS REPLY MAIL

FIRST CLASS PERMIT NO. 33391 BOSTON, MA

POSTAGE WILL BE PAID BY ADDRESSEE

Attn: Jennifer Ware

EDN MAGAZINE  
275 Washington Street  
Newton, MA 02158





# PHILIPS

## Looking for total 68000 development ability?

TEST & MEASUREMENT - DEVELOPMENT AND TEST SYSTEMS

Then look to one of the world's leading suppliers of the 68000 microprocessor and peripheral chips: Philips – parent company of Signetics.

And to make sure we keep that lead, we have one of the broadest ranges of 68000 support tools to choose from.

Three development systems, for example: the two-user PEDS; the multi-user PMDS 2 and the PC-based PMDS 3.

A Compiler Package, PCP, featuring a cross-software family of assemblers and compilers that use standard language definitions, and even allow mixing of languages.

And HLL debuggers that allow you to debug your program as it runs in your target at the same level of 'abstraction' as the program was written in, e.g., C or PASCAL.

You can even choose your host: PEDS, PMDS 2, PC-AT, or VAX with complete source compatibility.

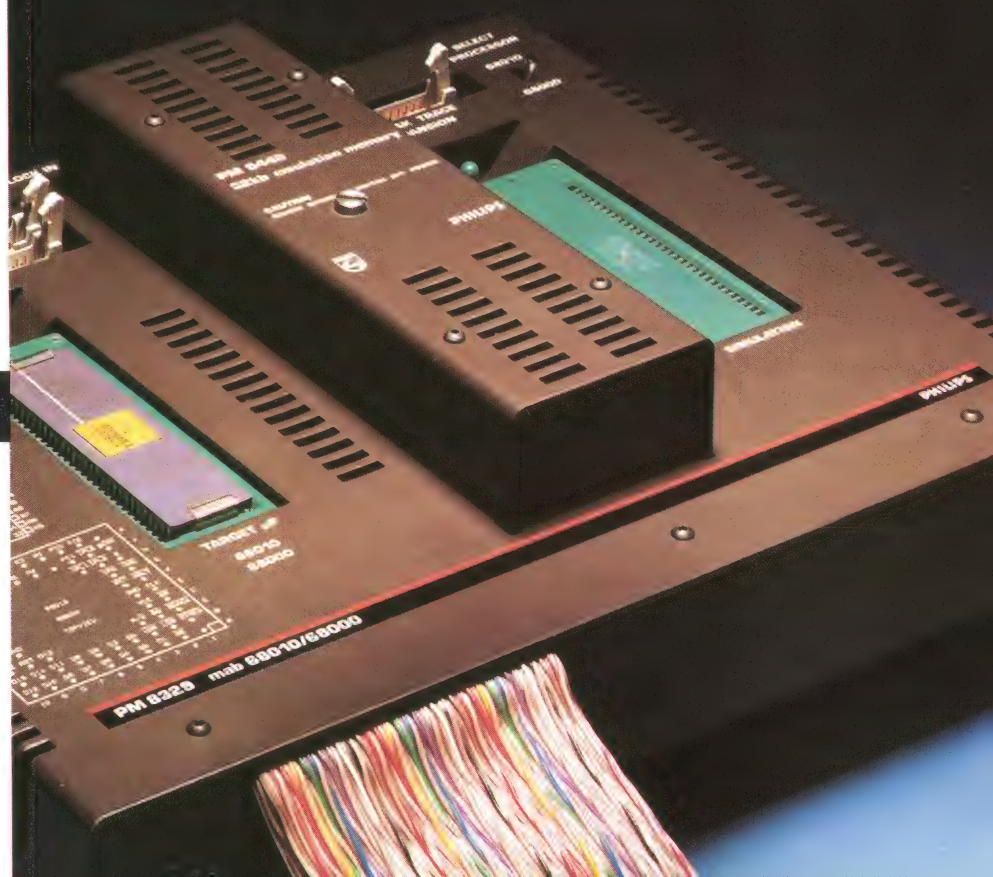
Moreover, as Philips is one of the world's largest manufacturers and users of microcontrollers, microprocessors and development tools, you will be looking to a single supplier who understands all your needs perfectly.



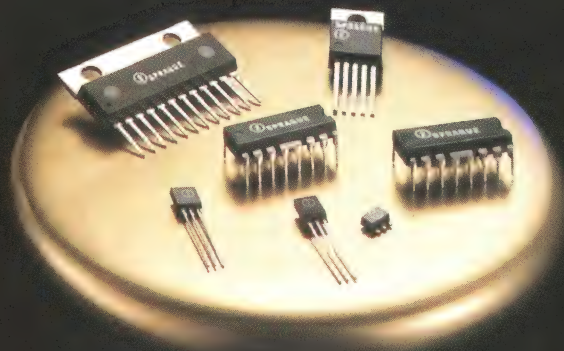
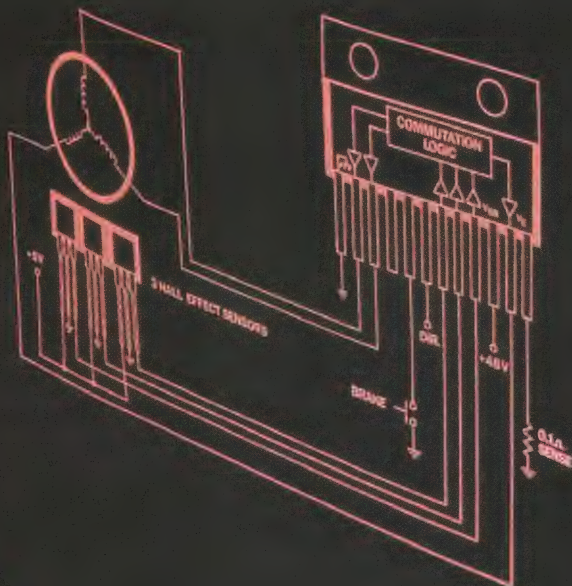
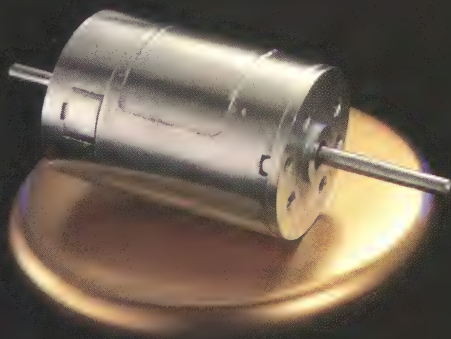
## Made to measure

Write to: Philips I&E, T&M department, Building HKF 70, 5600 MD Eindhoven, The Netherlands or call your local supplier: **Austria** (222) 62 91 41; **Belgium** (2) 525 66 92/94; **Denmark** (1) 57 22 22; **Finland** (0) 525 72 25; **France** (1) 49 42 80 00; **Germany** (561) 50 10; **Great Britain** (0223) 35 88 66; **Ireland** (1) 69 33 55; **Italy** (39) 36 35 240/8/9; **Netherlands** (40) 78 28 08; **Norway** (2) 68 02 00; **Portugal** (1) 68 31 21; **Spain** (1) 40 42 20 00; **Sweden** (8) 78 21 80 00; **Switzerland** (1) 48 82 21 1

**Advanced technology  
made to measure**



# SENSIBLE DRIVING.



## SPRAGUE HAS IT ALL FOR BRUSHLESS DCs.

Sprague is the only company that makes *all* of the electronics for brushless dc motors. Sprague makes a wide range of brushless motor drivers: unipolar, half-bridge, full-bridge, dual full-bridge, 3-phase: some with commutation logic. Sprague also makes Hall Effect IC sensors for use as brushless dc motor commutators.

These solid state devices not only have long life but operate accurately over extended temperature ranges and survive in punishing environments. You can count on Sprague to give you the right match of power ICs and Hall Effect sensors for sensible driving of brushless dc motors. May we tell you more? Sprague Electric Co., Semiconductor Group, Worcester, MA. For applications assistance, call 800/247-2077 (in Mass., 800/247-2076). For Motor Driver Brochure WR-202, Hall Effect Application Guide CN-207, and Data Sheet 29318.20 write to Technical Literature Service, Sprague Electric Company, P.O. Box 9102, Mansfield, MA 02048-9102.

CIRCLE NO 31

 **SPRAGUE**  
THE MARK OF RELIABILITY  
SEMICONDUCTOR GROUP

4SS-6136P

# TECHNOLOGY UPDATE

## Telecomm ICs offer improved functions for telephone- and PABX-system designs

Dave Pryce, *Associate Editor*

The latest offerings from telecomm-IC manufacturers not only continue the general trend toward higher integration by incorporating more functions than previous telecomm ICs did—they also substantially improve on those functions. Many of these just-introduced telecomm ICs offer economical ways to upgrade your telephone and PABX designs.

In the last few years, ICs have taken over many telephone and PABX functions that were previously performed by electromechanical circuitry. In telephone handsets, for example, the bulky electromagnetic bell has gone the way of the dinosaur, relegated to extinction by monolithic tone ringers that drive a small permanent-magnet speaker or a piezoelectric transducer. Speech amplification, in conjunction with other functions on the same IC, has allowed designers to replace the carbon-granule microphone with a more reliable dynamic type. Monolithic pulse- and tone-dialer ICs now replace the archaic rotary dialing mechanism, and speakerphone ICs now let designers create compact systems that permit hands-free conversations.

For PABX applications, monolithic SLICs (subscriber-line interface circuits) provide a number of functions, including the replacement of the hybrid transformer that's normally required for the 2- to 4-wire conversion. For trunk-line and central-office applications, which have tougher specifications for longitudinal balance, you can find monolithic ICs that employ magnetic compensation to reduce the size and cost of the transformer. And at least two very recent ICs let you eliminate the



*Forming the basis for a complete telephone, this module from Rohm includes a DTMF dialer, a speech network, and a tone ringer.*

transformer in even the toughest applications.

Of the early tone ringers that replaced the electromagnetic bell in telephones, the most successful was probably the ML-8204 from Mitel, which was later offered by a number of alternate-source suppliers. Literally millions of these ICs were used in inexpensive telephones during the phone glut between 1983 and 1985. This chip had shortcomings, however. It couldn't easily drive a piezoelectric transducer, and it required an external bridge rectifier

and zener diode to interface with the phone line.

The ZN488E from Ferranti solves both of these problems, as well as providing other features. The ZN488E (Fig 1) includes an on-chip bridge rectifier for direct-line operation, and you can use this IC with either piezoelectric or magnetic transducers. A standard 560-kHz ceramic resonator controls the clock-oscillator frequency, and internal frequency dividers provide selectable output frequencies of either 1000 and 1250 Hz or 1167 and

# THE ONLY WELL-MARKED SERIAL E<sup>2</sup> MIGRATION PATH.



**Only Xicor lets you migrate from 2K to 16K—with no hardware development detours.**

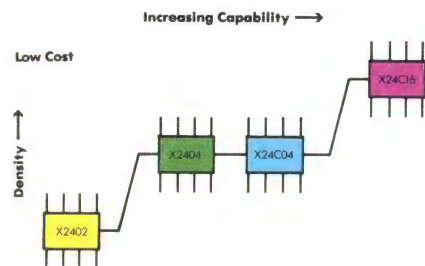
Sooner or later, your E<sup>2</sup>PROM-based designs are going to be headed for an upgrade. And when they are, you'll be glad you designed in Xicor serial I/O parts. Because they're the direct route from low- to high-density applications. The *only* direct route.

Xicor's family of 2K, 4K and 16K serial E<sup>2</sup>PROMs offer pin-for-pin compatibility, up and down the line. They're ideal for data storage in single-chip microcontroller designs, when field reprogrammability is

essential. In these applications—where data lines are limited—interface requirements can be reduced to a *simple, two-wire bus structure*. So you save both on board space and on component costs.

No matter what serial E<sup>2</sup>PROM path you take, Xicor stays with you all the way. At the low end, we offer a 256-bit NOVRAM, X2444, that's actually two memories in one: a 256-bit SRAM, overlaid with a nonvolatile 256-bit E<sup>2</sup>PROM. And at the high end, our CMOS parts feature low-power operation—well suited for *portable designs*.

Throughout the line, Xicor serial E<sup>2</sup>PROMs deliver reliable performance in applications that require extended endurance, with data retention greater than 100 years. They're available in commercial, industrial and military temperature ranges. And backed by Xicor's on-site technical design support.



So if your designs need economical storage options today *plus* easy growth potential tomorrow, check with Xicor. We're the only supplier who can get you on the right track now. And keep you on it—farther down the road. Call (408) 432-8888 today, or write: Xicor, Inc., 851 Buckeye Court, Milpitas, CA 95035.

**Xicor**

**MAKES IT MEMORABLE**

# TECHNOLOGY UPDATE

1333 Hz. The IC switches between the selected frequencies at a 10-Hz rate to generate a warbling ringing tone. A key feature of the ZN488E is its excellent dial-pulse rejection, which is accomplished by means of internal digital filtering. Housed in an 8-pin plastic DIP, the device costs \$1.35 (1000).

Although it's not a tone ringer per se, the TCM1520A from Texas Instruments detects the ringing signal from the telephone line and converts it to an output suitable for driving an optocoupler or TTL, NMOS-logic, or CMOS-logic device. The TCM1520A will work with either isolated or nonisolated supplies. It's used principally in feature phones and autoanswer modems to activate other equipment after a specified number of rings. In a typical application, the device is activated by the telephone line ringing voltage of 40 to 150V at 16 to 68 Hz. The IC provides an inverting output for driving external logic. Packaged in an 8-pin DIP, the TCM1520A costs \$1.01 (100).

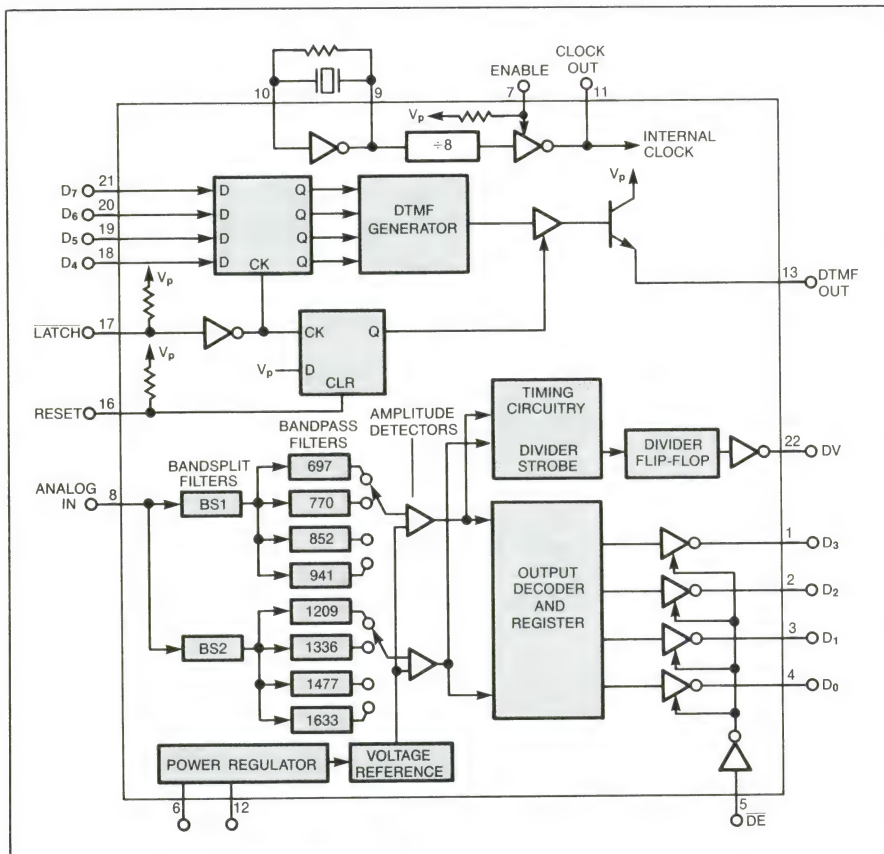
## Listen to the tones

The replacement of the rotary dialing mechanism with pushbuttons has brought with it a number of

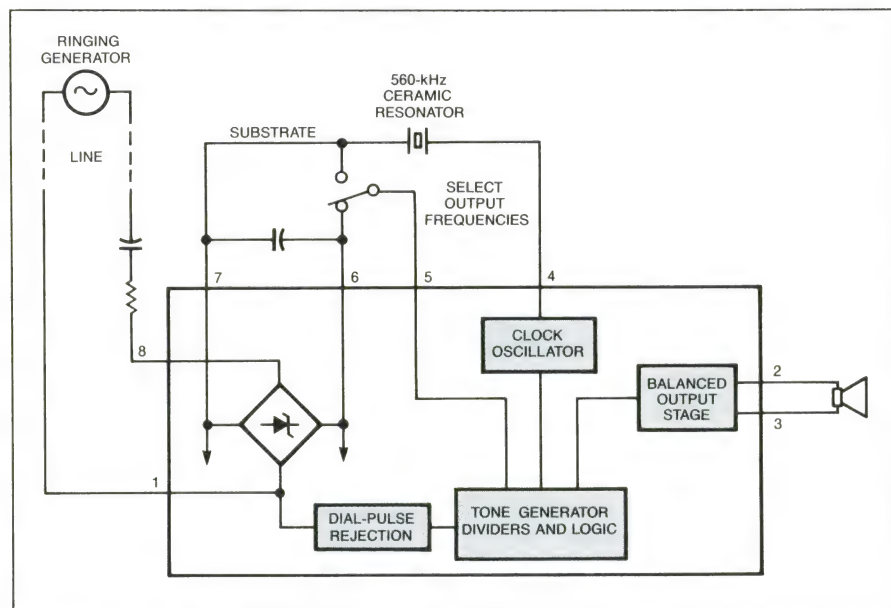
monolithic ICs that replicate the dial pulses or generate DTMF (dual-tone multiple-frequency) signals (as in AT&T's Touch Tone phones). Al-

though pulse-dialing applications are rapidly fading as the telephone networks switch over to DTMF, a number of manufacturers such as Gould/AMI, Mostek, Plessey, and SGS still supply ICs for pulse dialing. The 2560-type device, for example, is still popular and is available from several suppliers. For DTMF applications, manufacturers of telephone ICs offer a variety of products, such as the PCD3310 from Philips and Signetics, which provides both pulse- and DTMF-dialing functions.

Silicon Systems offers a complete circuit for DTMF applications. Its SSI-20C89 chip is actually a transceiver that not only generates and detects all 16 standard DTMF codes but also provides a microprocessor interface. The DTMF receiver section of the SSI-20C89 (Fig 2) detects the presence of a valid tone pair on the telephone line, indicating a single dialed digit. Pin 8 ac-



**Fig 2—For DTMF transceiver applications, the SSI-20C89 from Silicon Systems generates and detects all 16 standard DTMF signals. The circuit provides a microprocessor interface for tone-signal generation.**



**Fig 1—Able to drive either piezoelectric or magnetic transducers, the ZN488E tone ringer from Ferranti includes an on-chip bridge rectifier for direct-line operation.**

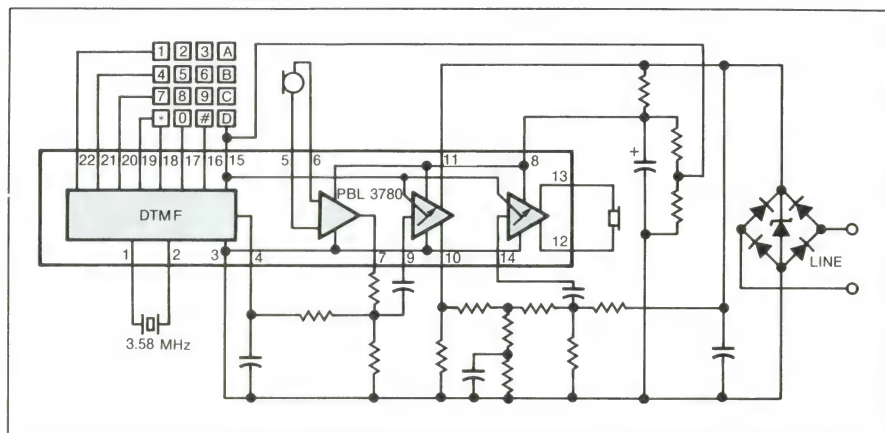
cepts the analog input signal which then goes through eight bandpass filters that detect the individual tones. The digital postprocessor times the tone durations and provides the correctly coded digital outputs. The chip's 3-state outputs facilitate bus-oriented architectures and drive standard CMOS circuitry. A low-cost, 3.579545-MHz color-burst crystal provides the time base for the digital functions and the switched-capacitor filters.

The transmitter (DTMF generator) section of the 20C89 provides performance similar to that of the Mostek MK5380, but has a tighter specification for output amplitude range and includes the addition of independent latch and reset controls. The DTMF generator on the 20C89 responds to a hexadecimal code input. Pins D<sub>4</sub> through D<sub>7</sub> are the data inputs for the generator. A high-to-low transition at the LATCH input results in the internal latching of the hexadecimal code and the generation of the appropriate DTMF tone pair. A high on the RESET pin disables the DTMF output, which will not be enabled again until the circuit latches in new data. The SSI-20C89 costs \$8.48 (1000).

ICs such as the SSI-20C89 are useful in consumer products such as telephone-answering machines. The DTMF receiver section, for example, allows the consumer to ring the answering machine from any DTMF telephone and activate a playback of the messages by simply pushing one of the telephone's dial buttons.

## One-chip telephones

Exemplifying the trend toward incorporating multiple functions on a single chip, the PBL-3780 from Rifa (Fig 3) is essentially a 1-chip telephone. This multipurpose IC contains the DTMF generator for tone dialing, the speech network for 2- to 4-wire conversion and amplification of the signal from the microphone (and from the line to the receiver), and a simplified tone ringer.



**Fig 3—Essentially a 1-chip telephone**, the PBL-3780 from Rifa includes a DTMF generator for tone dialing, a speech network for 2- to 4-wire conversion and signal amplification, and a simplified tone ringer.

the addition of several transistors and a few passive components.

A key feature of the PBL-3780 is its ability to work at low current and low voltage—which is important in equipment intended for use in residences, where several phones are sometimes connected in parallel. The PBL-3780 is well suited for use in telephone handsets. The benchmark for telephone handsets is the traditional, passive, type 2500 telephone set, which uses a transformer. Such telephones don't rely on electronics for speech transmission, and they're capable of functioning at currents of a few milliamps. The PBL-3780 functions at currents as low as 2.5 mA and at voltages under 1.5V.

Adding to the versatility of the PBL-3780 is the option it allows you of configuring the DTMF input pins (normally connected to the keypad) to a 4-bit latched data port. You can use this port to control the DTMF generator, thereby facilitating the use of a repertory dialer such as the Rifa PBM-3915 or a single-chip microprocessor to perform advanced dialing functions. The PBL-3780 sells for \$2.48 and the PBM-3915 for \$2.25 (10,000).

Rohm Corp touts its BP3003 as a 1-chip telephone, but it's not really a 1-chip circuit at all. The BP3003 is actually a small (1.5×2.25-in.) printed-circuit module that includes three separate monolithic ICs, a ce-

ramic oscillator, and an assortment of transistors, diodes, and passive components. The monolithic ICs provide the basic functions of a DTMF dialer, a speech network, and a tone ringer. Because of its small size and low profile, this ready-to-use functional module fits easily into compact telephones. The BP3003 contains all of the electronics required for a complete telephone. The only components you need to add are the handset, a piezoelectric speaker, and the keypad. Evaluation samples cost \$25.

## Speakerphone chips

Among this year's crop of new telecomm ICs are improved speakerphone chips. These devices are a welcome development, because many earlier attempts at designing speakerphone chips were less than fully successful.

The basic difference between a speakerphone and a telephone handset lies in their operation. The handset is a full-duplex device that allows simultaneous conversations in both directions. In the handset, the microphone is physically separated from the receiver and little, if any, acoustic feedback can occur to cause oscillations. Of necessity, speakerphones use half-duplex operation, allowing conversation to take place in only one direction at a time to prevent the proximity of the microphone to the speaker from causing

# There Will Still Be a Few Uses for Conventional ECL ASICs.



*Cold facts: now the highest-density ECL logic array runs at a cool 1/10 the gate power of competing devices.*

Raytheon's ASIC design expertise and proprietary technology make conventional ECL arrays too hot to handle. The superior performance of the new CGA70E18 and CGA40E12: the ECL logic array family with the highest density and the lowest power requirement now available.

□ **Superior performance:** 300 pS delay and 300  $\mu$ W (typical gate) power dissipation deliver the industry's lowest speed-power product: <0.1 pJ. Toggle frequency 1.2 GHz (typical).

□ **Highest density:**  
CGA70E18 — 12540 equivalent gates  
CGA40E12 — 8001 equivalent gates

□ **Lowest power:** Industry's smallest bipolar transistors result in power dissipation that is a fraction of conventional ECL at comparable propagation delays. Typical chip power dissipation of 3W to 5W.

□ **Et cetera:** Interface TTL, ECL (10K, 10KH, 100K), ETL. Customer access to proven, fully integrated CAD system. Commercial and military operating ranges.

Call Raytheon for access to the right ECL technology. We're not blowing any smoke, and neither should your system's performance.

Raytheon Company  
Semiconductor Division  
350 Ellis Street  
Mountain View, CA 94039-7016  
(415) 966-7716

*Access to the right technology*

**Raytheon**

CIRCLE NO 29

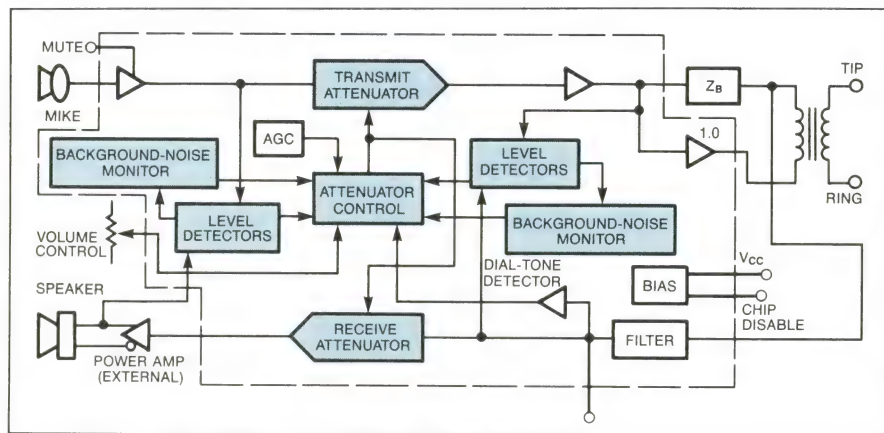
# TECHNOLOGY UPDATE

any "howling," or self-oscillation.

Although you may still have difficulties with the physical placement of the microphone and the speaker in your speakerphone design, the newer speakerphone ICs can ease your task, because manufacturers now have a better understanding of the overall requirements of speakerphones and the functions the ICs must have to overcome the inherent problems in speakerphone design.

A second-generation speakerphone chip from Motorola, for example, offers a number of improvements over its predecessor. You can use the chip to design a high-performance speakerphone system. The MC34118 (Fig 4) is a voice-switched circuit that features background noise monitors for both the transmit and the receive paths, 4-point signal sensing for improved sensitivity, an improved attenuator-gain range of 52 dB between transmission and reception, and the ability to operate at low voltage (3 to 6.5V) for line-powered applications.

The MC34118 includes an on-chip microphone amplifier with an ad-



**Fig 4—This second-generation speakerphone circuit—the MC34118 from Motorola—is a voice-switched circuit that includes background-noise monitors for both the transmit and the receive paths, 4-point signal sensing, and the ability to operate at low voltage.**

justable gain and mute control, and a dial-tone detector to prevent the attenuation of the dial tone by the receiver's background-noise monitor circuit. The chip also includes two line-driver amplifiers that you can use to form a hybrid network in conjunction with an external coupling transformer. The chip requires you to add an external power amplifier to drive the speaker, as you often had to do with earlier Motorola speakerphone ICs. The MC34118

costs \$4.00 in a 28-pin DIP and \$4.24 (100) in a 28-pin SOIC package.

Rifa offers a selection of three speakerphone ICs, including two unconventional CMOS types that are essentially advanced building blocks for high-quality speakerphones. The CMOS types use resistor ladders and digitally controlled analog switches to perform the variable gain/attenuation functions. The PBL-3786 bipolar type is a more conventional analog circuit

## For more information . . .

For more information on the telephone ICs discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

**Ferranti Electric Inc**  
87 Modular Ave  
Commack, NY 11725  
(516) 543-0200  
Circle No 685

**Gould Semiconductor Div**  
3800 Homestead Rd  
Santa Clara, CA 95051  
(408) 246-0330  
Circle No 686

**Mitel Semiconductor**  
360 Leggett Dr  
Kanata, Ontario  
K2K 1X5 Canada  
(613) 592-5630  
Circle No 687

**Motorola Inc**  
Semiconductor Products  
Box 20912  
Phoenix, AZ 85036  
(800) 521-6274  
Circle No 688

**National Semiconductor Corp**  
2900 Semiconductor Dr  
Santa Clara, CA 95051  
(408) 721-5000  
Circle No 689

**Philips Elcoma Div**  
Box 523,  
5600 AM Eindhoven  
The Netherlands  
(040) 757-005  
TLX 51573  
Circle No 690

**Plessey Semiconductors**  
9 Parker Rd  
Irvine, CA 92718  
(714) 472-0303  
Circle No 691

**Plessey Semiconductors Ltd**  
Cheney Manor  
Swindon, Wiltshire  
SN2 2QW, UK  
0793-36251  
TLX 449637  
Circle No 692

**Rifa**  
3255-4D Scott Blvd  
Santa Clara, CA 95054  
(408) 988-3603  
Circle No 693

**Rifa AB**  
S-163 81  
Stockholm, Sweden  
08-757 50 00  
TLX 8125008  
Circle No 694

**Rohm Corp**  
8 Whatney  
Irvine, CA 92718  
(714) 855-1669  
Circle No 695

**SGS Semiconductor Corp**  
1000 East Bell Rd  
Phoenix, AZ 85022  
(602) 867-6100  
Circle No 696

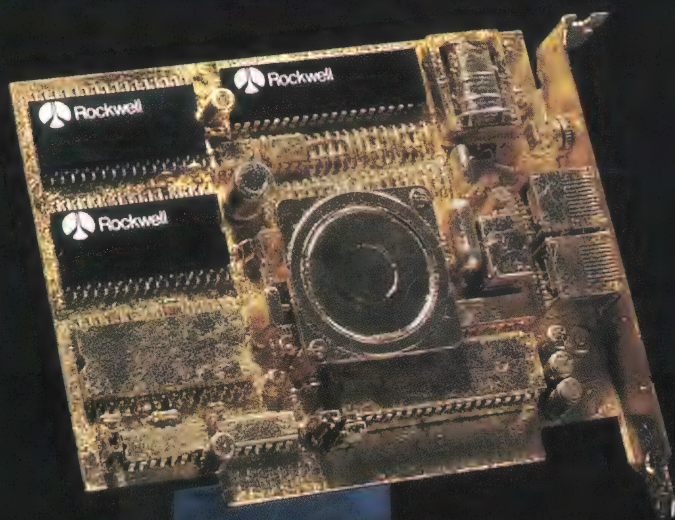
**Signetics Corp**  
811 E Arques Ave  
Sunnyvale, CA 94088  
(408) 991-4571  
Circle No 697

**Silicon Systems Inc**  
14351 Myford Rd  
Tustin, CA 92680  
(714) 731-7110  
Circle No 698

**Texas Instruments Inc**  
Semiconductor Group (SC-766)  
Box 809066  
Dallas, TX 75380  
(800) 232-3200 ext 700  
Circle No 699

**Thomson Components-Mostek Corp**  
1310 Electronics  
Carrollton, TX 75006  
(214) 466-7220  
Circle No 700

# ROCKWELL 2400 bps MODEM TECHNOLOGY HAS CHAMPIONED A MILLION SUCCESSES.



1,000,000th  
Modem Shipped  
Rockwell International

Rockwell International's commitment to quality and service helps our customers get to market faster with reliable, cost-effective 2400 bps OEM modem products.

With over a million Rockwell-based V.22bis modems in use worldwide, our R2424 full-duplex 2400 bps modem has set the de facto standard for V.22bis dial-up performance and reliability.

The R2424's versatile design allows easy integration into a variety of products, and includes a standard microprocessor bus interface for terminals and box-modem applications, integral modems and PC cards. Like all of our standard OEM modems, the R2424 is backed by a 5-year warranty.

To learn how our solutions can help put you in the lead, talk to the leader in proven modem technology.

#### Semiconductor Products Division

Rockwell International, P.O. Box C,  
M.S. 501-300, Newport Beach, CA 92658-8902  
(800) 854-8099. In California, (800) 422-4230.

Or contact the Rockwell office nearest you:

Santa Clara, CA, USA (408) 980-1900

Marlton, NJ, USA (609) 596-0090

Tokyo, Japan 81-3-265-8808

Hounslow, England 44-1-577-2800



**Rockwell  
International**

...where science gets down to business

Aerospace / Electronics / Automotive  
General Industries / A-B Industrial Automation

# TECHNOLOGY UPDATE

that is optimized for line-powered circuits.

The PBL-3786 can operate at a supply voltage as low as 2.6V, which allows it to work on a wide range of telephone lines. The chip includes internal voltage regulation for its biasing and overvoltage protection, continuous speech-attenuation characteristics for soft-switching between transmit and receive modes, and a speaker amplifier with automatic volume attenuation. An unusual feature of the chip is its inclusion of a tone ringer, which most speakerphone chips don't include. The PBL-3786's tone ringer takes advantage of the built-in speaker amplifier. The chip sells for \$3.75 (10,000).

## Subscribing to the line

The basic functions of a subscriber-line card at the telephone exchange are described by the BORS(C)HT standard. BORS(C)HT is not beet soup, but an acronym that stands for Battery, Overvoltage, Ringing, Supervision, (Codec), Hybrid, and Test. The most difficult of these functions to perform with a monolithic IC is the hybrid function, which traditionally uses a transformer for the required 2- to 4-wire conversion. This conversion includes changing from balanced transmission on the 2-wire side to a single-ended transmission on the 4-wire

side. The FCC requires the part that performs the hybrid function to exhibit longitudinal balance in order to reduce crosstalk on the lines, so the bulky transformer has been difficult to replace with an IC.

Typical SLIC de-feed circuits supply 20 to 100 mA of current, depending on the length of the loop. To handle these large currents without saturating, the transformer employs magnetic laminates. The transformer must also have a large inductance value to satisfy return-loss and frequency-response specifications. To satisfy both these requirements, the transformer must be rather large.

One way to reduce the size of the transformer yet still meet the FCC specs for longitudinal balance is to use a technique called magnetic compensation. National Semiconductor (TP3200) and Texas Instruments (TCM4207A) offer monolithic ICs that are specifically designed to provide magnetic compensation. (For a complete description of the National Semiconductor device, see "Magnetic compensation gives new life to transformer-based SLICs," EDN, April 30, 1987, pg 149.)

The TP3200 and the TCM4207A ICs use the current in a tertiary winding on the transformer to cancel the dc flux (caused by loop current) in the main windings. This action prevents the transformer

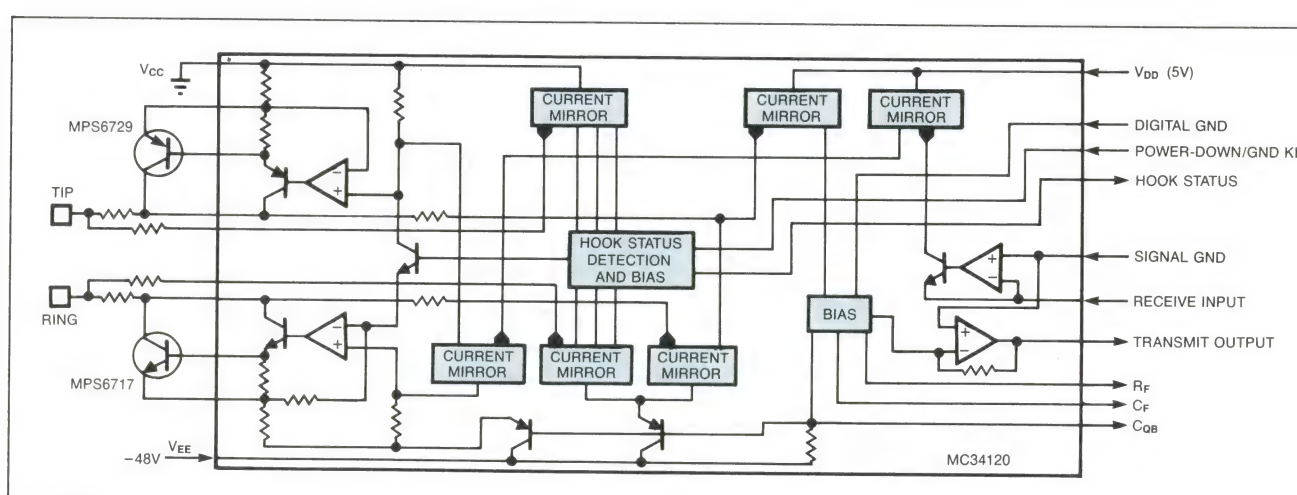
from saturating and allows you to use a small ferrite core. Special circuits in the ICs measure the current by sensing the voltage across a matched set of battery resistors and, with proper adjustment, exactly cancel the dc flux in the other windings. By using magnetic-compensation ICs, you can achieve a longitudinal-balance of greater than -60 dB.

Although they're not identical in construction and features, both the TP3200 and the TCM4207A provide not only magnetic compensation but also all of the other functions normally required in a SLIC. In a 22-pin DIP, the TP3200 costs \$3.75 (1000). In a 24-pin ceramic DIP, the TCM4207A costs \$7.38 (1000).

## Eliminating the transformer

Even though the technology for the transformer-based SLIC is a well-proven one, many designers would like to replace it with a monolithic IC. Unfortunately, until recently, no widely available monolithic IC could provide the required performance—particularly with regard to the specifications for longitudinal balance. Now, however, Motorola and Rifa offer devices that appear to be capable of doing that.

The Motorola MC34120 (F) and the Rifa PBL-3762 achieve



**Fig 5—Because it provides all the basic functions for a subscriber-line interface, the MC34120, along with a codec, can replace the transformer in PABX systems and other applications.**

1

# Discover the Power of Integrated CAE Design Capture and Verification.

IN A SERIES

**Tektronix  
Aided  
Engineering**

Finding the most powerful electronic design solutions is now easier than ever, thanks to the Designer's WorkSystem.™

Developed by Tektronix as part of Tektronix Aided Engineering, the Designer's WorkSystem combines design capture and verification tools into one powerful solution.

Designer's Database Schematic Capture (DDSC™) provides you with a fast, user-customizable, menu-driven system for design capture of IC and PCB schematics.

From that same DDSC user interface, you can create graphic and textual descriptions of your circuit stimulus and run one of our powerful design verification tools, HILO®-3 Logic Simulation System or SPICE™2G.6 analog simulator. Graphical simulation results are easy to view using our interactive graphical circuit probe capability.

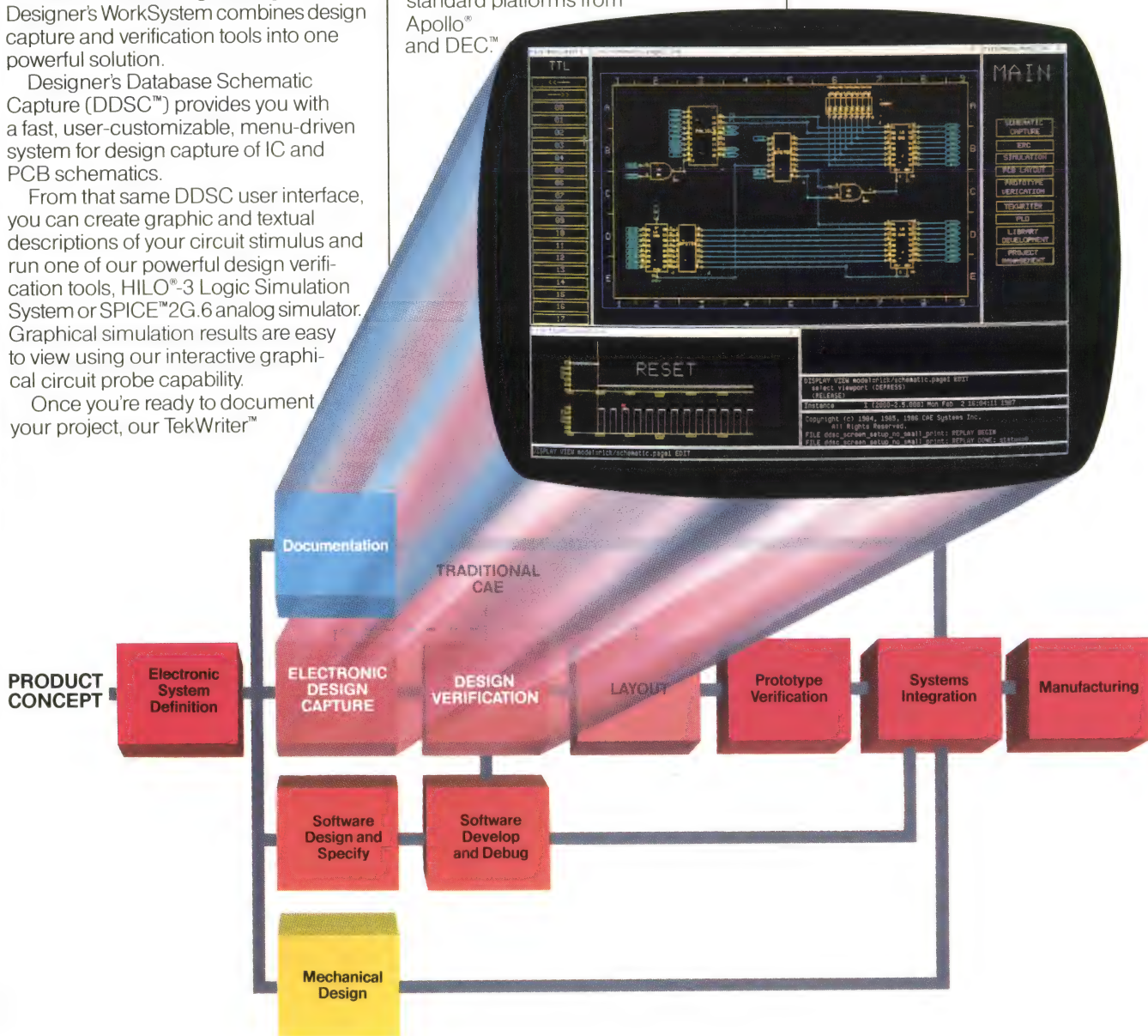
Once you're ready to document your project, our TekWriter™

Engineering Design Documentation System (based on Interleaf™) lets you merge DDSC design schematics and simulation data with professional text formats and other graphics for fast, camera-ready documentation.

It's all part of Tektronix Aided Engineering. A family of integrated WorkSystems addressing each area of your electronic design cycle. From design capture, verification and documentation to IC and PCB layout. All running on industry-standard platforms from Apollo® and DEC™.

Best of all, it's from Tektronix. The name you've always trusted to get the engineering job done. So you're assured of worldwide service, support and training.

To discover the power of Tektronix Aided Engineering, contact your local Tektronix, CAE Systems Division, sales office. Or call 800/547-1512. Tektronix, CAE Systems Division, P.O. box 4600, Beaverton, OR 97076.



WorkSystem, DDSC, TekWriter are trademarks of Tektronix, Inc. HILO is a registered trademark of GenRad, Inc. SPICE is based on Berkeley SPICE, University of California at Berkeley. Interleaf is a trademark of Interleaf, Inc. Apollo is a registered trademark of Apollo Computers, Inc. DEC is a trademark of Digital Equipment Corporation.

**Tektronix**  
COMMITTED TO EXCELLENCE

# SINGLE-SLOT /AT SOLUTIONS AVAILABLE NOW!

## CAT902

10 MHz, 1 wait: Up to 1 meg RAM. 128K PROM: Dual floppy controller: SCSI hard disk interface: 1 parallel and 2 serial ports: EGA and 80287 optional: Keyboard port, speaker, reset / key lock / turbo ports



## CAT910

CAT900 Features plus: EGA extended resolution (1280 x 800): CGA and monochrome modes: 1280 x 800, 640 x 480, 640 x 350, and 640 x 200 resolutions



## CAT911

CAT 901 Features plus: EGA extended resolution (1280 x 800): CGA and monochrome modes: 1280 x 800, 640 x 480, 640 x 350, 640 x 200 resolutions



## CAT901

12 MHz, 0 Wait: Dynamic clock speed change: Up to 4 meg RAM. 64K PROM: PROM set-up routines: Dual floppy controller: ST506 hard disk interface: 1 parallel and 2 serial ports: EGA and 80287 optional: Keyboard port, speaker, reset / keylock / turbo ports

## CAT900

12 MHz, 0 wait: Up to 8 meg RAM. 64K PROM: 1 parallel and 2 serial ports: EGA and 80287 optional: Keyboard port, speaker, reset, keylock, turbo port

## CAT912

CAT902 features plus: EGA extended resolution (1280 x 800): CGA and monochrome modes: 1280 x 800, 640 x 480, 640 x 350, and 640 x 200 resolutions

### QUANTITY CUSTOM DERIVATIVES AVAILABLE

#### PACKAGING SUPPORT

- Backplanes • Card Cages • Fans • Plug-In Power Supplies • Low Profile Enclosure
- Small Footprint Enclosure • Industrial Chassis • Rack Mount Chassis Design



CALL 1-800-443-2667

IN MS 601-856-4121

P.O. BOX 748 • Ridgeland, MS 39158

CIRCLE NO 9

## UPDATE

hybrid function by using a separate codec/filter circuit, and both devices carry impressive specifications for longitudinal balance. The specs are difficult to compare, however, because they're stated somewhat differently.

The MC34120's data sheet shows a 2-wire spec of -58 dB at 300 Hz and 1 kHz, and -53 dB at 3 kHz. The PBL-3762's 2-wire specs are -60 dB between 200 Hz and 1 kHz, -50 dB between 1 and 4 kHz, and -63 dB between 300 Hz and 3.4 kHz. Of the two devices, the Rifa device appears to have somewhat better specs in the 300-Hz to 3-kHz range, but it's not certain, because Motorola and Rifa obtained their results under different conditions. Rifa, however, claims that the PBL-3762 will meet or exceed all FCC specifications for longitudinal balance.

The first samples of the MC34120 are planned for March or April 1988; the company expects to offer them for \$6.80 (100) in either 20-pin DIPs or 20-pin SOIC packages. The PBL-3762 (in a 22-pin DIP) is in production; it costs \$8.95 (10,000).

The parts discussed here are representative of the wide variety of telecomm ICs on the market: You can choose from literally hundreds of different types. From simple tone ringers to complex speakerphone chips to high-performance SLICs, ICs are available to satisfy almost any telecomm function in telephone-handset and PABX systems. **EDN**

Article Interest Quotient  
(Circle One)

High 515 Medium 516 Low 517

# ENCODER



93¢\*  
EACH

- For cursor, scan, position sensing, and robotics applications
- Up to 400,000 operations
- Detented or non-detented versions
- All quadrature two bit codes

\*5000 lots for standard shafts and codes.

920 Rathbone Avenue • P.O. Box 1528  
Aurora, Illinois 60507 USA  
FAX 312/844-4286  
312/844-4300

**STANDARD  
GRIGSBY**  
We Switch The World

CIRCLE NO 10

# The CY233-

# LINC\*

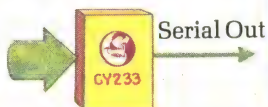
\* Local Intelligent Network Controller

*connects your world so  
many ways at such  
a low price!*

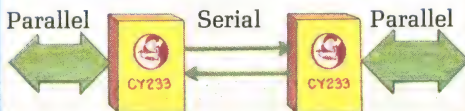
- 5v 40 pin CMOS
- 300 Baud to 57.6K Baud
- Selectable Token support
- Numerous Operational Modes
- \$75/ea., \$30/(100)

## Parallel to Serial

Parallel  
TTL  
Data &  
Strobes



## Wire-Saver

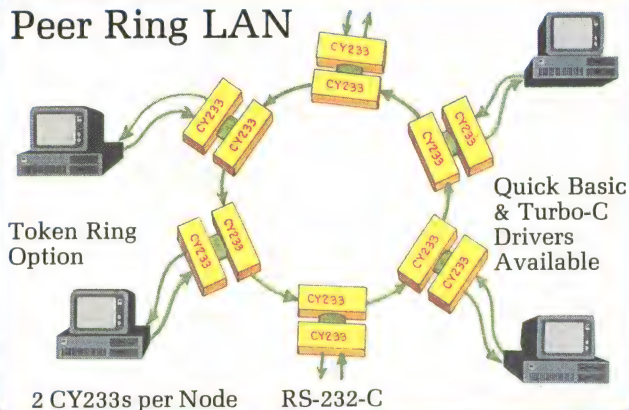


## Serial to Parallel

Serial  
In → Parallel Out,  
Strobes &  
Mode  
Selection



## Peer Ring LAN



## Host Ring

Serial Ring Network with up to  
255 Nodes or Stations (2048 I/O Lines)

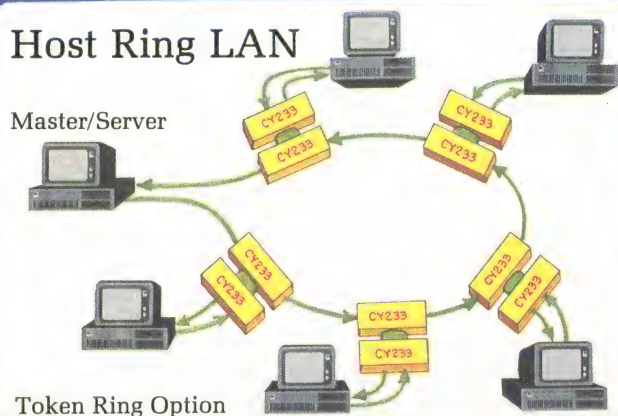


## Party Line

Alternate Topology for 256  
8-Bit Ports or 2K I/O Lines



## Host Ring LAN



**Cybernetic Micro Systems, Inc.**

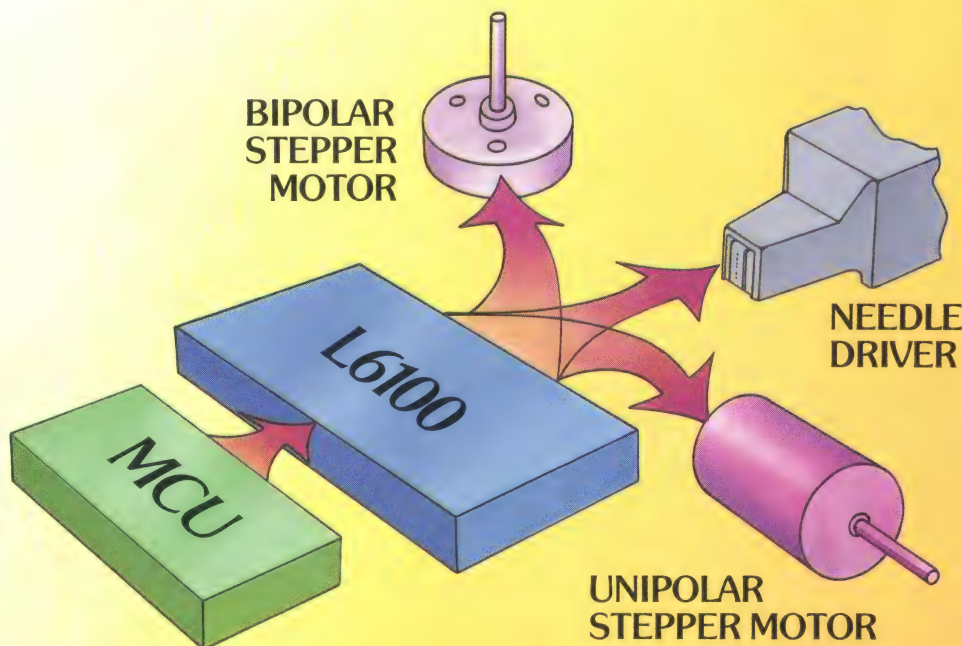
Box 3000 • San Gregorio, CA 94074 • USA  
(415) 726-3000 • Telex: 910-350-5842

- ☐ Rush free data sheet on the CY233-LINC
- ☐ Send \$10 User Manual
- ☐ Send Manual and \_\_\_ chips at \$75 ea. + \$5 Shipping
  - ☐ California Residents add Sales Tax
  - ☐ Check enclosed ☐ Charge my MC/VISA/Amex card
  - Card # \_\_\_\_\_ expire \_\_\_\_\_ sign \_\_\_\_\_

Name \_\_\_\_\_ Title \_\_\_\_\_  
Company \_\_\_\_\_ Phone \_\_\_\_\_  
Address \_\_\_\_\_ Mail Stop \_\_\_\_\_  
City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_

EDN010788

# WHO CAN PUT POWER MOSFETS



SGS-THOMSON Microelectronics--The Brighter Power--of course. The L6100 and L6102 are implemented in our unique Multipower-BCD™ technology, which allows complete isolation of the output MOSFETs. At 100V and 5A/8A, the L6100/2 opens up a whole spectrum of design possibilities.

The L6100/2 is a more economical, more reliable and more compact alternative to using four discrete MOSFETs.

Compared to darlingtons, the L6100/2 offers much lower dissipation, no secondary breakdown and an intrinsic free wheeling diode in each transistor.

The L6100, now in full production, is available in an 18 lead DIP package with a special leadframe that conducts heat to the PCB copper. The L6102—soon to be in full production—comes in SGS-THOMSON's own industry standard 15 pin Multiwatt® package.

Regardless of whether you're driving unipolar DC motors, stepper motors, needle solenoids or many other types of loads—the fast switching, easily paralleled L6100/2 delivers the economy and reliability to turn design possibilities into realities.

---

$V_{DS}$ Max	100V min
$I_D$ (Powerdip) (Multiwatt)	1.5A cont., 5A peak 2.0A cont., 8A peak
$R_{DS(ON)}$	1.2 Ohms max
Packages	Powerdip (18 pin) L6100 Multiwatt (15 pin) L6102

---

SGS-THOMSON Microelectronics has sales offices in:

Australia, Austria, Belgium, Brazil, Canada, China, Denmark, France, Hong Kong, India, Italy, Japan, Korea, the Netherlands, Singapore, Spain, Sweden, Switzerland, Taiwan, United Kingdom, USA, West Germany.

# FOUR ISOLATED IN A SINGLE CHIP?

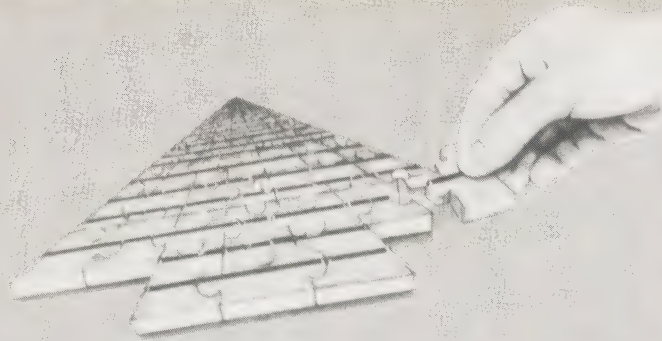
SGS-THOMSON's exclusive Multipower-BCD™ technology—that's integrated Bipolar, CMOS, DMOS—has a lot more to offer. What other smart power IC technology isolates the DMOS output power transistors to let you connect as many as you need on a chip anyway you like? None.

That's just one example of how smart our power really is. And the L6100 is just one of many SGS-THOMSON smart power products.

Why not get the full story on SGS-THOMSON Multipower-BCD™ technology plus full data on the L6100. Call your local sales office today. After all, the brighter your smart power source, the brighter your design's future.



**SGS-THOMSON**  
MICROELECTRONICS



# BUSCON:

**Putting Together the Best  
in the Industry**

Solving the puzzle of board-level applications, and the jigsaw of appropriate bus architectures, takes an increasing amount of concentration. With focused technical sessions, seminars, and exhibits, BUSCON/88-West puts the pieces together all in one place, at one time. If you're involved in the design, application and/or specifying of single-board microcomputers and expansion boards, BUSCON/88-West is for you.

## SEMINARS:

A Technical Look at Bus Structures • VMEbus Overview • VSB: A VME Subsystem Bus • NuBus Designing with Message Passing Coprocessor Futurebus • IBM's Microchannel Architecture

## SESSIONS:

Backplane Systems • Real-Time Operating Systems Interfaces • High-Speed Processing • High Performance SCSI • Tools, Tips and Techniques Analog I/O Applications • Real-Time Kernels System Architecture • Communications I/O Applications Linking UNIX to a Real-Time Environment • Multiprocessing

## EXHIBITS FEATURING:

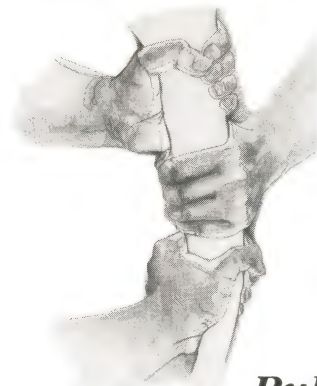
Connectors • Software • Systems Integrators Board/Systems Manufacturing and Marketing Surface Mount Devices • PC Bus • Multibus I Multibus II • Q-bus • Futurebus • STD Bus • VME Bus NuBus • S-100 Bus • STE Bus • G-64 Bus • CAMACbus Cimbus • Bibus • SMP Bus • Exorbus BITbus • Fastbus • Versabus • SCSI

FOR COMPLETE INFORMATION: Write or telephone  
Anne Weber, Project Manager  
CMC • 222 Fashion Lane, #201 • Tustin, CA 92680  
Telephone (714) 669-1201 • FAX: 714 669-9105

# BUSCON 88-West

The Bus/Board Users Show & Conference  
**February 22-25, 1988**  
Disneyland Hotel  
Anaheim, California

**BUSCON will run concurrent with the Power  
Electronics Conference and NEPCON/West**



**Power  
Electronics  
Conference  
Team  
WORK**

*Pulling Together  
the Best in Designers & Users*

# The Power Electronics Conference/88-West

**For Users/Integrators & Designers of  
Power Sources and Related Components**

■ **Date/Location:** February 22-25, 1988  
Disneyland Hotel • Anaheim, California

## ■ Characteristics:

A focused technical conference that concentrates on application needs of both power electronics designers and users/integrators. It provides opportunities to learn new techniques, the latest power topologies, and to exchange applications ideas with fellow engineers. Technical exhibits tie the "hardware dimension" to the "intellectual software" of sessions and seminars.

## ■ Technical Sessions:

Quality and Reliability • Battery Applications • Military Power Supplies • Systems Design • The Specifying Art • Circuit Design-Basic • Circuit Design-Advanced • Magnetics Design • High Frequency Designs • Thermal Management

## ■ Tutorial Seminars:

Power Supply Basics • Thermal Design • Enhanced Measurements • Circuit Analysis • Regulatory Agencies Multi-output Power Supplies • Power Devices • Introduction Control Loops • EMC Basics • Japanese Marketing Techniques

## ■ User/Designer Symposia:

Systems Integrator Symposium • The Components Clinic

## ■ Relevant Exhibits:

~135—displaying power supplies, sources, magnetic materials, test equipment, semiconductors, and related components, in an unhurried atmosphere.

## ■ Target Audience:

Real-time applications knowledge for senior engineering personnel, such as: Electrical Engineer, Sr./Design Engineer, Project Engineer, Sr. Development Engineer, Chief Engineer, Sr. Engineering Specialist, Development Engineer, Associate Engineer, CONS Engineer, Applications Engineer, R&D Mgr./Coordinator, Engineering Manager, Key Account Engineer, R&D Engineer, Consulting Engineer/Mgr., Sr. Test Engineer, Laser Engineer, Design PC Engineer, Components Engineer, Hardware Development Engineer, Transformer Engineer, Semiconductor Manager, Microcomputer Engineer, OEM Vendor Engineer, Technician, Radar Production Engineer, AMTS

## ■ Sponsors:

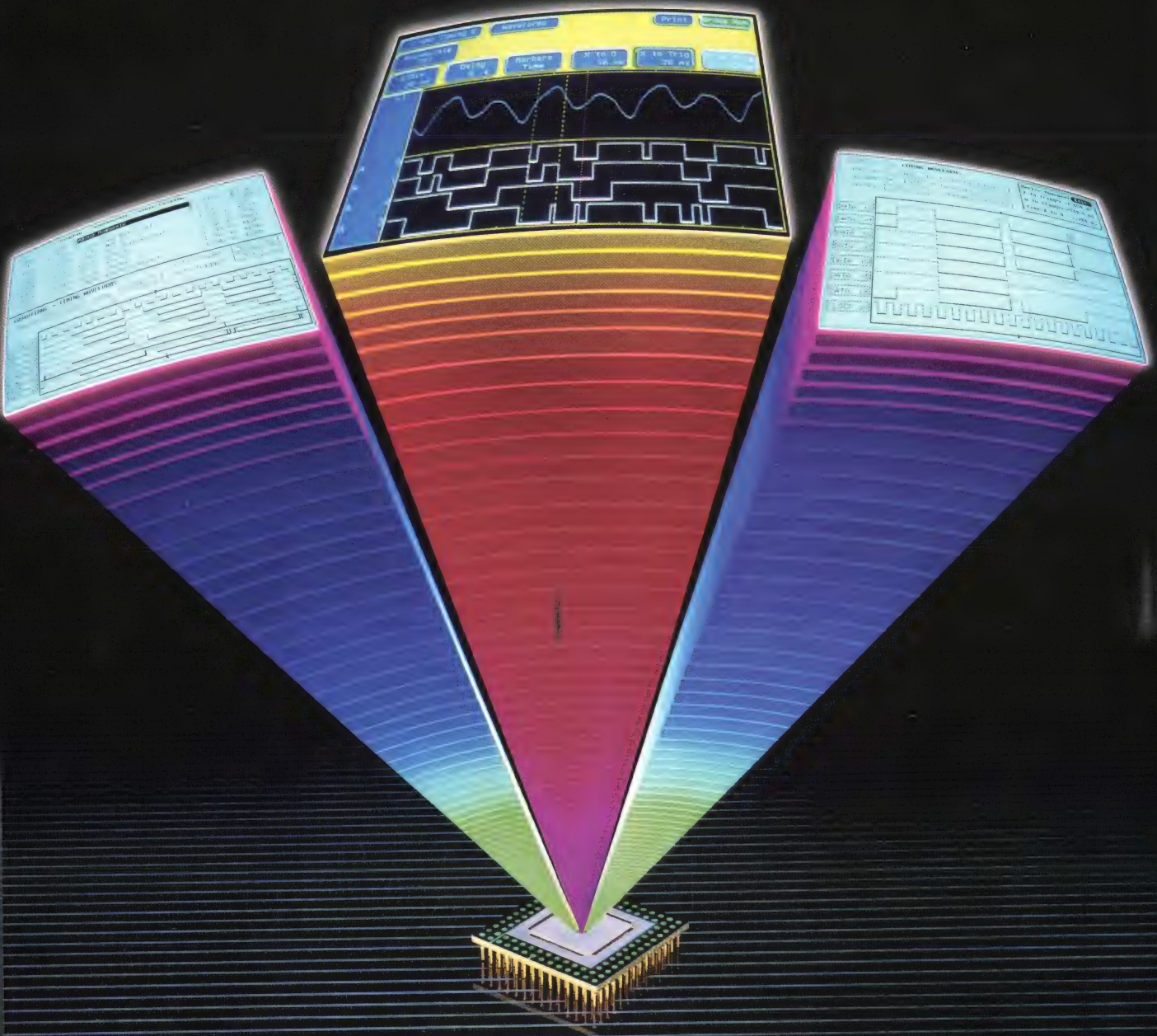
Power Sources Manufacturers Association  
Power Conversion Products Council International


## ■ Advance/Discount Registration Information

Write, telephone or FAX: Edward E. Grazda, Director of Education, PEC, 222 Fashion Lane, #201, Tustin, CA 92680 (714) 669-1201, FAX (714) 669-9105

**PEC WILL RUN CONCURRENT WITH  
BUSCON AND NEPCON/WEST.**

Hewlett-Packard's  
new logic analyzer family  
offers you something not found  
in other logic analyzers...





HP's new logic analyzer family gives you more of what you want in logic analyzers. For less.

So now measurements are easier to make. And high-quality HP logic analyzers are easier to buy!

You get the performance that best suits you: from 32 to 400 channels of 100 MHz transitional timing/25 MHz state, and up to 80 channels of 1 GHz timing analysis.

Our new family also offers you easy operation, powerful triggering, a CAE link, an oscilloscope, pattern generation, portability, built-in mass storage, simple probing, optional 3-year protection, and much more.

## The small secret behind the big value.

To give you more for your money, HP developed a Logic Analyzer-on-a-Chip containing a complete state analyzer, timing analyzer, and acquisition memory. This proprietary HP IC makes exceptional value possible...80 channels of 100 MHz transitional timing for only \$7,800\*.

You can assign state or timing in 16-channel increments. Get fully independent state, timing, state/timing, or state/state setups. Even time-correlate measurements on complex multiprocessor systems.

## Operational simplicity runs in the family.

We've made our controls even easier than before, without sacrificing performance.

You can make timing or state measurements using just three menus, so you never get lost. Triggering setups, from the simple to the complex, are a snap. And autoscale gives you one-button setup for timing analysis.

You even get a color touch-screen and knob, or optional mouse with the new HP 16500A. Color lets you quickly distinguish between menu choices, measurements, and results...and find glitches more easily.

## Probing made easy.

HP's new passive probes are lightweight and flexible...specially designed to grip easily and securely to your device under test. Plus, our preprocessors give you quick setups with most popular 8, 16, and 32-bit  $\mu$ Ps, including the Motorola 68020 and Intel 80386. And if you've already invested in HP preprocessors, we offer you an easy upgrade path.

---

## HP 1651A: full-featured logic analyzer for only \$3,900\*.

---

With 32 channels of 100 MHz transitional timing for just \$3,900\*, the HP 1651A gives the hardware engineer a highly economical, yet powerful debugging tool.

It's a full-featured logic analyzer with no compromises in state and timing capabilities (25 MHz state/100 MHz transitional timing on all channels), memory depth, triggering, or I/O features. It supports most popular 8-bit  $\mu$ Ps with full inverse assembly. Plus it's

compact, weighs just 22 lbs., and has an optional carrying case for easy transport.

---

## HP 1650A: the new standard in general-purpose logic analysis for just \$7,800\*.

---

The HP 1650A features time-correlated state/state or timing/state operation on 80 channels. Plus eight sequence levels to meet your toughest triggering tasks. Yet it's priced below \$8,000!

You get 25 MHz state/100 MHz transitional timing on all 80 channels, and preprocessor support for 8, 16, and 32-bit  $\mu$ Ps. And, the

# More value.

HP 1650A is portable, lightweight, and small enough to fit comfortably on a crowded workbench. It's also programmable, has a built-in disc drive for storing measurements, and provides hardcopy documentation.

through your choice of performance modules. You can have up to 400 channels of 25 MHz state/100 MHz transitional timing. 8 channels of full-featured, simultaneous scope analysis. 80 channels of 1 GHz timing. Or 204 channels of 50 Mbit/sec stimulus.

Just \$12,400\* buys you a

## Now, bring real-world measurements into the CAE environment.

The HP 16500A is part of HP DesignCenter...a product development environment that unites engineers from IC design/verification to PCB design and test. By linking the HP 16500A with HP CAE, you can compare measurement results and simulated data on your workstation, and use measurement results as your simulator patterns.



## HP 16500A: modular system solution, priced your way.

The HP 16500A is modular, with the flexibility to meet your debug, characterization, or pass/fail test application needs today and tomorrow. You get a combination of state, timing, oscilloscope, and stimulus-response capabilities

basic configuration with 80 channels of 25 MHz state/100 MHz transitional timing.

You can trigger one module with another. Time-correlate measurements between modules...400 Ms/sec scope and 1 GHz timing, for example. Even view state, timing, and analog on the same screen! Fully programmable, the HP 16500A eliminates the need for separate data storage and printer control. HP-IB and RS-232 are standard.

## Mail the card today!

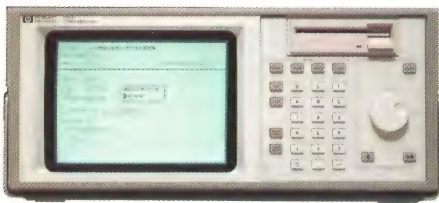
For more information, fill out and mail the postage-paid reply card today. Call us at 1-800-367-4772, Ext. 232W. Or contact your local HP sales office listed in the telephone directory white pages. Ask for the electronic instruments department.



**HEWLETT  
PACKARD**

## Excellent reliability, service, and support.

When you purchase a logic analyzer from HP, you get high reliability. The support you need to be productive with your instrument quickly. And a worldwide sales and service network to ensure your continuing satisfaction for years to come.



**HP 1651A \$3,900 \***

The HP 1651A is a general-purpose, low-cost 32 channel logic analyzer with many features normally found on more expensive analyzers.

- 100 MHz transitional timing on all 32 channels.
- 25 MHz state on all channels.
- Support for most popular 8-bit  $\mu$ Ps.
- Fully programmable, with built-in disc drive and hardcopy output.
- Portable and compact — weighs just 22 lbs.
- Optional 3-year protection.



**HP 1650A \$7,800 \***

The HP 1650A is a general-purpose logic analyzer with a range of features to satisfy many requirements in design and test.

- 100 MHz transitional timing/25 MHz state on all 80 channels.
- Support for most popular 8, 16, and 32-bit  $\mu$ Ps.
- Configurable as 2 totally independent analyzers.
- Fully programmable, with built-in disc drive and hardcopy output.
- Eight sequence levels with storage qualification, pattern and range recognizers.
- Glitch capture on all channels.
- Optional 3-year protection.



**HP 16500A**

The HP 16500A is a modular, configurable system solution that can meet a wide variety of logic analysis, oscilloscope, and stimulus-response measurement requirements.

- Configurable through your choice of performance modules:
  - 25 MHz state/100 MHz transitional timing (80 channels per module) \$5,200 \*
  - 400 Ms/sec 100 MHz bandwidth digitizing oscilloscope (2 channels per module) \$5,500 \*
  - 1 GHz timing (16 channel master) \$7,800 \*
  - 50 Mbits/sec pattern generation (12/48 channels per module) \$3,700/\$4,000 \*
  - Mainframe \$7,200 \*
- Color touchscreen and knob, with optional mouse.
- Intermodule triggering.
- Two built-in disc drives.
- Fully programmable, with RS-232 and HP-IB interfaces.
- Optional 3-year protection.

\* U.S. list price.

Motorola 68020 is a trademark of the Motorola Corporation.  
Intel 80386 is a trademark of the Intel Corporation.



**HEWLETT  
PACKARD**

## Analog comparators achieve high speeds, but application challenges remain

David Shear, *Regional Editor*

High-speed analog comparators have always presented design challenges, and the state-of-the-art devices listed in **Table 1** (pg 76) are no exception. When applying them, you'll have to overcome such device limitations as inherent instability, varying propagation delays, low gain, high input bias current, narrow input-voltage ranges, input slew-rate limits, strange supply-voltage requirements, and high cost.

It's not that manufacturers haven't attacked these problems—it's simply that victory in one area generally involves a retreat in others. The biggest struggle involves combining in one device two conflicting parameters:

- High gain, to allow the comparator to resolve small differences at its input, and
- Wide bandwidth (or short propagation delay), to allow the comparator to operate at high speeds.

Two TTL-compatible devices illustrate the type of tradeoff that manufacturers of high-speed monolithic comparators are forced to make between gain and speed: The Signetics/Philips NE5105A has a gain of 18,000, but a propagation delay of 50 nsec; in contrast, VTC Inc's VC7696 has a propagation delay of 10 nsec but a gain of only 400.

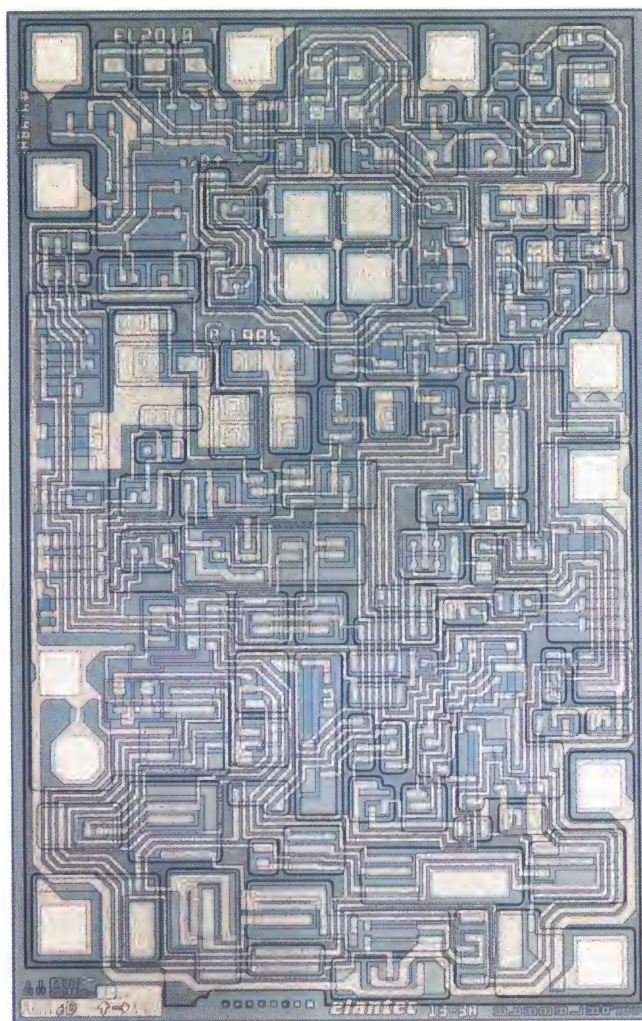
Despite the sacrifices in gain or bandwidth that manufacturers make, the devices nevertheless exhibit a tendency toward instability. To minimize this tendency, you should, when laying out a comparator circuit, place a ground plane under the comparator and any associated parts. In addition, place power-supply bypass capacitors close to the device.

These precautions reduce the primary cause of oscillations: parasitic capacitance. As the output changes state, current flows to the input through this capacitance. The current in turn can alter the level at the input and cause the output to change state once again. That second, and inappropriate, change can again affect the input, with the result that the output bursts into oscillation.

In addition to employing layout techniques that minimize parasitic capacitance, you can take other approaches to eliminating oscillation. One is to make sure that the input signal is fast enough to drive the device through its linear region before oscillation can begin. This approach is fine if you have control of the incoming signal, but usually you don't.

As another approach, you can provide feedback from the comparator's output to its noninverting input to establish hysteresis. According to this approach, when the output changes state, the feedback signal forces the noninverting input through the active region to keep the output from oscillating.

Vendors, too, take steps to minimize the risk of oscillation. Most high-speed comparators, for instance, have a latch on their output. Although one function of such a latch is to support synchronous acquisition, it also helps to suppress os-



**Fig 1—The large blocks of metal, which you can see in the left center of this die photo of Elantec's EL2018, are replaced by a second latch in the otherwise-identical EL2019. The second latch implements the EL2019's flip-flop.**

# TECHNOLOGY UPDATE

cillations. The latch gives you control over the output, which can change only when you allow a change. The latch effectively disconnects the input from the output, thus breaking the feedback path.

Latched comparators have two modes of operation, transparent and latched, which you control via a latch-enable input. To control the latch, the latch-enable pulse must be long enough to allow the latch to operate, but short enough so as not to re-establish input-to-output feedback and allow oscillation.

## A latch gives you control

The EL2019 from Elantec simplifies control of the latch by using a master/slave flip-flop. The device is similar to the EL2018, which has a simple latched output rather than the flip-flop. From a manufacturing

standpoint, the only difference between the devices lies in the final stages of metallization (Fig 1).

The rising edge of the clock input controls the EL2019's flip-flop. Thus, you needn't worry about pulse width, as you would with the simple latch. With the EL2019, the pulse can be as long as you desire.

The EL2019's approach proves beneficial because it's usually much easier to find a clock edge in a circuit than it is to find a pulse with just the right timing. In a successive-approximation analog/digital converter, for instance, you can use the clock that controls the converter's successive-approximation register to latch an EL2019.

## Achieve nearly infinite gain

The use of a latch creates a nearly ideal comparator—one whose gain

approaches infinity. Fig 2 shows the transfer function of a typical comparator using a latch and one not using a latch. The resolution of the latched comparator is limited by its own noise.

All comparators have a specified propagation delay: the time it takes a signal to get from the input to the output. You'll notice in Table 1 that propagation delays are often specified with an associated overdrive voltage: the input differential voltage in excess of the value required to cause an output transition.

For some comparators, a larger overdrive reduces the propagation delay, and manufacturers' specs can make it difficult to judge the devices' relative performance. In Table 1, each propagation-delay spec was measured using a 100-mV input signal, but with overdrive lev-

**TABLE 1—REPRESENTATIVE HIGH-SPEED ANALOG COMPARATORS**

MANUFACTURER AND DEVICE	COMPARATORS/PACKAGE	PROPAGATION DELAY/OVERDRIVE (nSEC MAX/mV)	VOLTAGE GAIN (V/V MIN)	INPUT BIAS CURRENT ( $\mu$ A MAX)	INPUT OFFSET VOLTAGE (mV MAX)
<b>ANADIGICS</b> ACP10010	1	1.0/20	100	0.10	30
<b>ANALOG DEVICES</b> AD96685	1	3.5/10	—	10	2
AD96687	2	3.5/10	—	10	2
<b>ELANTEC</b> EL2018	1	30/5	15,000	0.30	3
EL2019	1	—	—	0.30	5
<b>HARRIS</b> HMD-11685-2	1	0.5/— (TYP)	10@100 MHz 1.5@2 GHz	0.10	—
<b>HONEYWELL</b> HCMP96850	1	3/10	4000 (TYP)	20	3
HCMP96870A	2	2.3/10	4000 (TYP)	20	3
HCMP96900	2	4.2/50 (TYP)	1000 (TYP)	20	3
<b>PLESSEY</b> SP93802	2	<1/10 (TYP)	20	9	3.5
SP93804	4	<1/10 (TYP)	20	9	3.5
SP93808	8	<1/10 (TYP)	20	9	3.5
<b>PRECISION MONOLITHICS</b> CMP-08	1	9.5/5	800	13	2.5
<b>SIGNETICS/PHILIPS</b> SE/NE5105A	1	50/5	18,000	1.2	0.25
<b>VTC</b> VC7690	1	1.8/10	400	20	5
VC7695	1	1.8/10	400	20	5
VC7696	1	10/10	400	10	3
VC7697	2	1.9/10	400	20	5
VC7698	2	10/10	400	10	3

# TECHNOLOGY UPDATE

els ranging from 5 mV or less to as much as 50 mV.

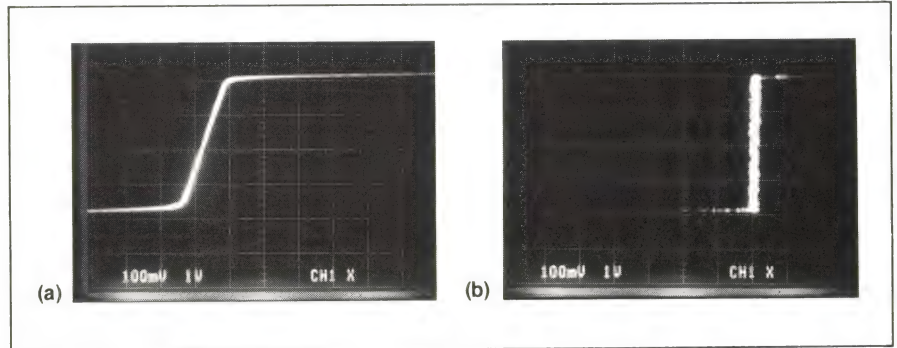
When the propagation delay is optimized, the gain usually suffers. Therefore, you might have to sacrifice speed in gain-critical applications such as A/D conversion, for which the gain must be high enough to resolve the least significant bit. For an ADC that has a 10V input range using logic that requires 2V signals, the minimum gain is 410 for 10-bit resolution, 1639 for 12-bit resolution, and 26,212 for 16-bit resolution.

On the other hand, other applications might be more sensitive to speed than to gain. In automatic-test-equipment, line-receiver, and instrumentation applications, the input is often a relatively large signal, and a gain as low as 100 might be adequate. Although such applica-

tions might not demand high gain, they might well require fast comparators with small variations in propagation delay.

Such devices include those in the SP9380X family from Plessey. They have a gain of only 20, but a propagation delay of less than 1 nsec. The

analog front end (Fig 3) is a gain block that amplifies the signal to a level sufficient to allow the latch to determine the appropriate output. The latch circuitry is regenerative, so once the output latches, the gain of the device goes from 20 to nearly infinity. This approach allows the



**Fig 2—The transfer function of Elantec's EL2018 (a), operating in a transparent mode, shows the limitation of its gain as the input moves through the active region. In the latched mode, the EL2019 (b) has a gain limited only by the noise of the input. For both photos, the vertical scale is 1V/div, and the horizontal scale is 100  $\mu$ V/div.**

COMMON-MODE-VOLTAGE RANGE (V MAX)	SUPPLY VOLTAGE (V)	OUTPUT COMPATIBLE	OUTPUT TYPE	POWER DISSIPATION (mW MAX)	PRICE	COMMENTS
+1/-2	+5/-5	ECL (SINGLE ENDED)	DIRECT	200	\$19.50 (1000)	
+5/-2.5	+5/-5.2	ECL	LATCHED	140	\$4.60 (100)	
+5/-2.5	+5/-5.2	ECL	LATCHED	280	\$6.40 (100)	
+12/-12	+15/-15	TTL/CMOS	LATCHED	400	\$4.50 (100)	3-STATE OUTPUT, POWER-DOWN MODE
+12/-12	+15/-15	TTL/CMOS	M/S FLIP-FLOP	420	\$4.50 (100)	3-STATE OUTPUT, POWER-DOWN MODE
+1.25/-2.25	+4.5/-3.5	ECL	LATCHED	1250	\$155 (100)	
+2.5/-2.5	+5/-5.2	ECL	LATCHED	125	\$6.19 (100)	
+2.5/-2.5	+5/-5.2	ECL	LATCHED	250	\$8.38 (100)	
+10/-3	+12/-7	ECL	LATCHED	720 (TYP)	\$15.31 (100)	
+2.6/-2.1	+5/-5.2	ECL	LATCHED	360	\$26.56 (1000)	GLITCH CAPTURE, ADJUSTABLE HYSTERESIS
+2.6/-2.1	+5/-5.2	ECL	LATCHED	360	\$46.04 (1000)	ONBOARD BANDGAP REFERENCE
+2.6/-2.1	+5/-5.2	ECL	LATCHED	640	\$69.05 (1000)	
+2.7/-3.0	+5/-5.2	ECL	DIRECT	210	\$3.35 (100)	8-PIN DIP WITH ECL OUTPUT
+3/-3	+5/-5	TTL	LATCHED	130	\$4.75 (100)	
+2.5/-2.5	+5/-5.2	ECL	DIRECT	300	\$7.21 (100)	8-PIN DIP WITH ECL OUTPUT
+2.5/-2.5	+5/-5.2	ECL	LATCHED	300	\$10.21 (100)	
+3.5/-3.5	+5/-5	TTL	LATCHED	300	\$7.21 (100)	
+2.5/-2.5	+5/-5.2	ECL	LATCHED	600	\$15.29 (100)	
+3.5/-3.5	+5/-5	TTL	LATCHED	300	\$10.71 (100)	

# TECHNOLOGY UPDATE

comparator to achieve subnanosecond propagation delays with the low-gain front end and still be able to resolve low-level input signals.

Each comparator in the SP9380X family also has a glitch-capture circuit, which detects whether the output exceeds 20 mV (or the input exceeds 1 mV) for more than 900 psec. If it does, the glitch-capture latch sets and remains set until the device receives a reset pulse. You can easily look for glitches in a time window by controlling the latch reset.

## Variations can be important

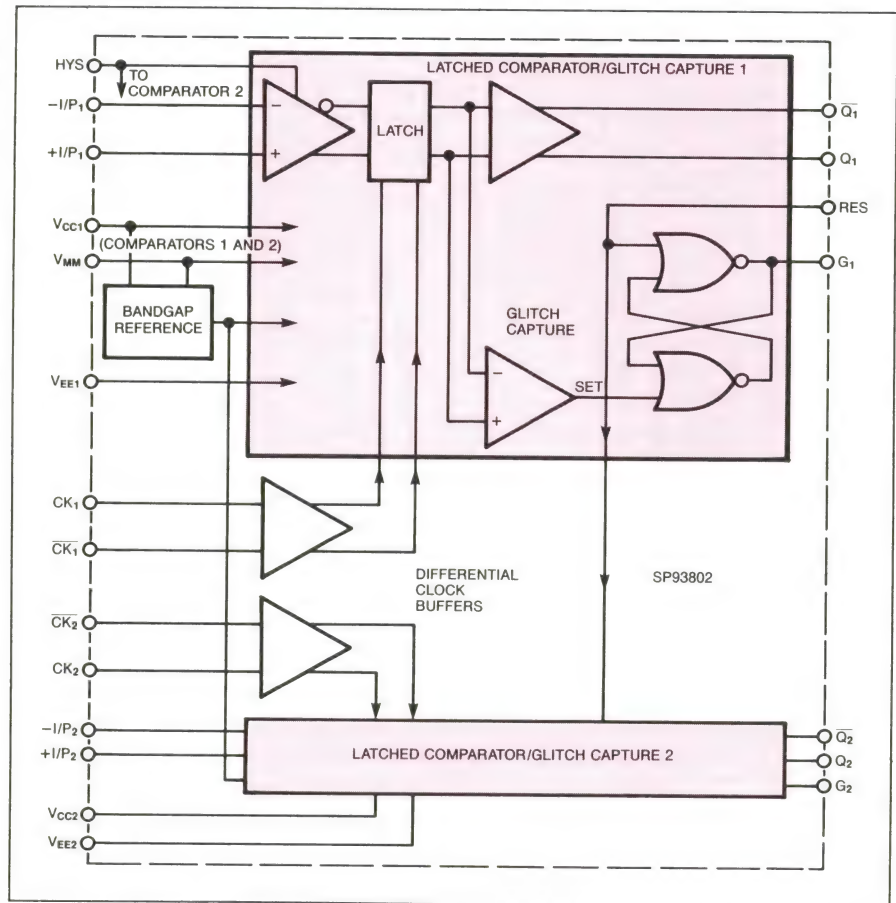
In some applications, changes in propagation delay can be as important as the delay spec itself. A comparator's propagation delay can vary with temperature, with input voltage, and between devices.

Analog Devices' AD96685/7 single and dual ECL-compatible comparators have a dispersion (the change in propagation delay throughout a range of input-overdrive levels) of 50 psec from 100 mV to 1V, and the propagation delay of Honeywell's HCMP96900 varies less than 100 psec (typ) despite changes in input voltage, input direction, and input overdrive.

Although Anadigics doesn't explicitly list a dispersion spec for its ACP10010 GaAs comparator, the data sheet does note that the propagation delay is 1.0 nsec with a 20-mV overdrive and 0.5 nsec with a 100-mV overdrive, implying a dispersion of 50% within the 20- to 100-mV overdrive range.

Even with constant overdrive levels, propagation delays vary from device to device—by an amount that's not always specified. One manufacturer that does provide this spec is Plessey. For its SP9380X family, the company specifies channel-propagation-delay matching of better than 100 psec for devices in the same package.

There's one more source of difficulty in interpreting propagation-delay variations, and it involves the



**Fig 3—Each channel in the Plessey SP9380X dual, quad, and octal comparators includes a comparator, an output latch, and glitch-capture circuitry.**

definition of the point at which you consider a transition to have occurred. For comparators with true/complement ECL outputs, you can determine the exact time of switching by using a test circuit that detects when the outputs cross. However, when only a single ECL output is available, as with the Anadigics ACP10010, it's more difficult to define the point at which the output transition occurs. You could define the exact time as the point at which the output voltage crosses the midpoint between the high and low output logic level; however, that 50% point depends on rise/fall times and might also depend on the load and other factors.

## A comparator must track

Propagation delay and dispersion aren't the only factors you have to consider when evaluating whether a comparator is fast enough for your

application. Another important, though rarely specified, parameter is the input slew rate. If the comparator's front end can't keep up with the slew rate of the incoming signal, then errors will result. Honeywell's ECL-compatible HCMP96900 can handle inputs with slew rates to 1500V/ $\mu$ sec, and Elantec's EL2018/19 can track a 300V/ $\mu$ sec slew rate.

## Input bias currents are high

Another challenge to your design is the input bias current. To meet this challenge, you might employ one of the few high-speed comparators that exhibit low bias currents. For example, the EL2018/19's input bias current is 0.30  $\mu$ A max, 0.10  $\mu$ A typ, and the GaAs comparators from Harris and Anadigics spec input bias currents of 0.10  $\mu$ A max.

Most high-speed comparators, however, have high input bias currents—in the range of tens of micro-

# Our newest sales angle is a straight line.

Time for some straight talk.

At ITT Cannon, we didn't survive in the interconnect business for 70 years without continually changing to meet the needs of the marketplace.

So when you asked for faster, more efficient servicing, we changed. We streamlined. We created a straight line access between customer and manufacturer.

Now it's easier than ever to do business with Cannon.

We made specialists out of our sales force so they can answer your product needs immediately. Or put you in touch with someone who can. The object is to give you a straight access to the person who can get the job done.

We added more manufacturer representative organizations and distributors across the country. Now there are hundreds of people in more cities to service you directly.

We're constantly updating our extensive sales network on the newest product information. So, when you deal with a Cannon salesperson, you not only get straight line delivery, but also straight line answers about any of our products.

No doubt about it. You expect us to keep up with your needs. We demand it.

Sales responsiveness. Part of the new story at Cannon.

Talk to us.

*Worldwide Headquarters  
10550 Talbert Ave.  
Fountain Valley, CA 92708  
Or call (714) 964-7400*

**ITT CANNON**  
*We're making progress.  
Not excuses.*

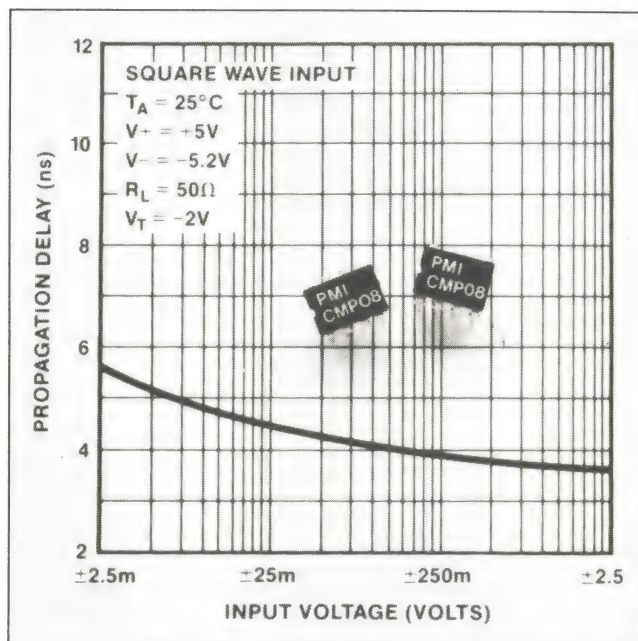
# TECHNOLOGY UPDATE

amperes. Such high input bias currents usually require that you include a FET buffer on the input.

Not only do you often need a buffer, but you might also need a voltage divider on the input. A scan of **Table 1** shows that most high-speed comparators have a rather narrow common-mode-voltage range, in the neighborhood of  $\pm 3V$ . The GaAs comparators have a common-mode-voltage range that's even narrower. The Harris HMD-11685-2 can only accept signals from +1.25 to -2.25V. Unfortunately, your inputs are likely to be  $\pm 12V$  max analog signals (from analog circuits powered by  $\pm 15V$  supplies) or -2 to +8V digital signals (from circuits made of CMOS-logic, ECL, or TTL devices).

## Wide input voltage range

To directly meet the needs of analog signals, the Elantec EL2018/19 devices can accept  $\pm 12V$  signals when powered from  $\pm 15V$  supplies, although their propagation delay is a relatively long 30 nsec. Honeywell's HCMP96900 is faster—4.2 nsec—but it nevertheless can accept



*A comparison of constant propagation delay with a signal*

input voltages of -8 to +13V, depending on the supply voltage. With a +12V and -7V supply (test conditions), the HCMP96900's common-mode voltage range is -3 to +10V. This range satisfies most ATE applications, but the device's 20- $\mu A$  input bias current might still require that you use a buffer.

The HCMP96900 offers yet another

er advantage: It can v input voltage that's 1V its supply voltage. Th power the comparator circuitry from one supply simple diode clamp to comparator's input. clamp to effectively pr parator whose input can voltages in excess of the age, the external supply to be at least one dioe than the comparator voltage.

## For more information . . .

For more information on the comparators described in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

**Anadigics Inc**  
 35 Technology Dr  
 Warren, NJ 07060  
 (201) 668-5000  
 TWX 510-600-5741  
 Circle No 701

**Analog Devices**  
 70 Shawmut Rd  
 Canton, MA 02021  
 (617) 461-3821  
 TLX 174059  
 Circle No 702

**Elantec Inc**  
 1996 Tarob Ct  
 Milpitas, CA 95035  
 (408) 945-1323  
 Circle No 703

**Harris Microwave Semiconductor**  
 1630 McCarthy Blvd  
 Milpitas, CA 95035  
 (408) 433-222  
 Circle No 704

**Honeywell Inc**  
 Signal Processing Technologies  
 1150 E Cheyenne Mountain Blvd  
 Colorado Springs, CO 80906  
 (303) 577-1000  
 TLX 452433  
 Circle No 705

**Philips Elcoma Div**  
 Box 523, 5600 AM  
 Eindhoven, The Netherlands  
 (040) 757005  
 TLX 51573  
 Circle No 706

**Plessey Semiconductors**  
 9 Parker  
 Irvine, CA 92718  
 (714) 472-0303  
 Circle No 707

**Precision Monolithics Inc**  
 1500 Space Park Dr  
 Santa Clara, CA 95054  
 (408) 727-9222  
 Circle No 708

**Signetics Corp**  
 811 E Arques Ave  
 Sunnyvale, CA 94088  
 (408) 991-4545  
 Circle No 709

**VTC Inc**  
 2401 E 86th St  
 Bloomington, MN 55420  
 (612) 851-5000  
 TLX 857113  
 Circle No 710

## Some unusual requirements

Powering a high-speed tor can entail difficulties those of meeting the r of an input-protection example, the Harris H requires the nonstanda of +4.5V and -3.5V, a eywell HCMP96900 pr plex power-supply-volta In contrast, Elantec's quite easy to power. I any level from  $\pm 5$  to  $\pm$  output remains TTL throughout that range.

The foregoing discu trates the tradeoffs you designing with high-spe tors. You might choose because its specs sug

# WHO YA GONNA CALL TO ICE 68020 BUGS? ATRON BUGBUSTERS!

We recently received a competitive analysis written by a billion-dollar competitor of ours. In it, they rank in-circuit emulation companies in order of importance. We were number one.

## SO WHO'S ATRON?

Today, Atron is the number-one supplier of hardware-assisted software debuggers for 8088/80286/80386-based PCs. Nine of the top ten software packages were written by Atron customers. Everybody from AST to Borland to Oracle to Zenith. Now, we can make the same claim in the 68020 marketplace.

Everybody from Apple (MAC IIs) to Wellfleet (datacom) will attest to the superiority of Atron's 68020 debugging technology. One Atron customer even said, "We sent our non-Atron ICE unit out several months ago for repairs; nobody around here seems to know or care if it's back yet. The Atron unit is the tool of choice."

## 25-MHZ, REAL-TIME, EMULATION: SOONER OR LATER, YOU KNOW YOU'LL NEED IT.

Why invest in a slower emulator (especially one that costs more)? Some bugs only occur in real time, and you know your next design will be 25 mhz. Before Atron's state-of-the-art design, there was no such thing as a 25-mhz emulator. There still isn't another one anywhere near our price.

## PROBE CAN TRACE IT THROUGH THE PIPELINE, SO YOU WON'T LOSE YOUR MIND.

The 68020 has an on-board pre-fetch pipeline. Without Atron's 68020 PROBE, your best software engineer will spend a lot of time figuring out which instructions actually execute, and then, which bus cycles go with those instructions. The 68020 PROBE eliminates all these

tedious mental translations and displays what the processor really did. The technology, called pipeline dequeuing, is only available from Atron. Because the Atron bugbusters are the only ones anywhere who've figured out how to do it. And it took us 100,000 lines of code. Consider it our contribution to your sanity. (It was a dirty job, but somebody had to do it.)

Accu Ray Advanced Digital  
Allen Bradley Apple Computer  
Arete Systems BBN Bell North  
Bally Sente Clearpoint  
Compugraphics Control Data DY-4 Sys-  
tems Douglas Aircraft Eastman Kodak Fla-  
vors Tech Forestyle General  
Electric Grafted IBM  
Kurzweil Computer  
Laser Co MAI/Basic Four  
Marquette Electronics  
McDonnell-Douglas  
McFadden Systems  
National Research  
Council Naval Ocean  
Systems Center Off-  
shore Systems Ltd. P-  
Can Robotics Palladium  
Data Plexus Computer  
Radius Republic Elec-  
tronics Rockwell Interna-  
tional Spartacus Stan-  
ford Telecommunications  
Versatec Vitro Services  
Wang Laboratories Wellfleet Communications  
Xyvision

### 68020 PROBE SPECIFICATIONS

Clock speed	25 mhz
Execution	Transparent
Trace	2048 cycles by 96 bits Qualified trace region Dequeued trace data Pre and center triggered Includes symbols and source Dynamic cache control 8 hardware on execute Read, write, fetch, logic Single or range addresses 16 software breakpoints Sequential triggers - 4 terms Real-time pass counter Guarded access on memory Output lines for cross trigger Input lines for external logic
Breakpoints	512K Yes for C, Pascal, Assembler S, Tek, Cof, 4.2 BSD, SUN and IEEE formats
Mapped RAM	Limited only by AT disk size
Source debug	Multiple windows and menus
Symbolic debug	Yes, and conditional execution To target system at 375k baud 68881,68851
Symbol table	
User interface	
Macros	
Download	
Coprocessor	

## LET THE SOURCE BE WITH YOU.

Why spend all day doing mental translations between your C source code and the machine code in your target? These tedious operations are eliminated with Atron's source-level debugging capabilities.

Since PROBE uses a PC AT as its instrumentation chassis, you can get compiled code to its target via Ethernet, VAXNet, SUNNet, SCSI or RS-232. And whether you are compiling on a PC, a workstation or a VAX, Atron supports more object-module formats than anybody else (see specification box).



## YOU'LL BE A BELIEVER AFTER A SHORT DEMONSTRATION.

So who ya gonna call? Bugbusters! Today. At 408/741-5900. Or send in the attached coupon.

My business card or company letterhead is attached:

- ☐ I've got to see this for myself. Please have a representative call me to schedule a demonstration.
- ☐ Please send me your 36-page 68020 PROBE user's guide, with its command summary and examples of use.

EDN010788



### BUGBUSTERS

A division of Northwest Instrument Systems, Inc.

20665 Fourth Street • Saratoga, CA 95070 • 408/741-5900

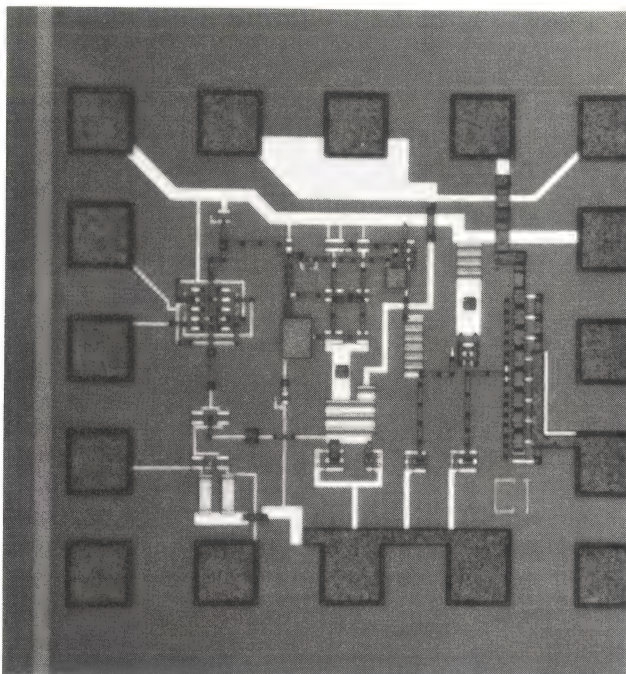
# TECHNOLOGY UPDATE

than-adequate gain or speed margins for your application. But, that device might have high bias currents and a narrow input range,

requiring input buffers and voltage dividers, and in turn possibly reducing your circuit's speed to unacceptable levels. Moreover, special pow-

er-supply requirements might drastically increase the complexity of the external circuitry.

Don't forget that you have to consider cost, too: High speed and high cost usually go hand in hand, but not always. For example, Precision Monolithics' CMP08 is a 9.5-nsec, ECL-compatible comparator that costs \$3.35 (100), and the AD96685 from Analog Devices is a 3.5-nsec device costing \$4.60 (100). **EDN**



*A 100-mV overdrive enables the ACP10010 from Anadigics to achieve a propagation delay of 500 psec. This GaAs comparator can maintain a gain of 100.*

## Reference

1. Fleming, Tarlton, "Design challenges attend application of monolithic voltage-comparator ICs," *EDN*, February 6, 1986, pg 45.

Article Interest Quotient  
(Circle One)

High 518 Medium 519 Low 520

## WINS/Streams™. The natural solution to UNIX connectivity.

Transparent. Portable. The natural evolution of TCP/IP for UNIX™. Such a natural, in fact, WINS/Streams is *the* UNIX V.3 communications

standard. Truly life-sustaining. For more information, call 800-872-8649 (in California 800-962-8649) or send us this ad with

your business card. The Wollongong Group, Inc., 1129 San Antonio Road, Palo Alto, Ca. 94303.

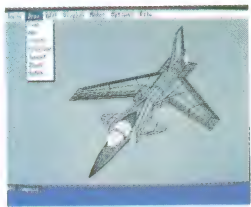
**WOLLONGONG**  
**We are the standard.™**

# AUTOCAD® RELEASE 9. ITS ENHANCEMENTS ARE EVIDENT.

AutoCAD's new release builds on the strengths of its eight predecessors. Here's how:

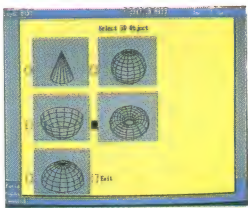
## PULL-DOWN MENUS.

Release 9's pull-down menus let you choose all of AutoCAD's fundamental commands with a click of your mouse or digitizer. You can also customize menus to provide your own frequently used commands. Pull-down menus are compatible with AutoCAD's proven system of screen and tablet menus.



## ICON MENUS.

When you wish to select 3-D objects, text fonts, or hatch patterns, for example, you can pick them from an icon menu that appears on the screen. You can do the same thing with objects you create on your own. Icon menus make it easier and faster to choose the option you want.



## DIALOGUE BOXES.

These let you converse with AutoCAD; give it instructions by "filling in the blanks." They can simplify many of your tasks—entering layer information, for example.



## FILE PORTABILITY.

With Release 9, drawing files are directly compatible without any conversion steps across four different operating systems on four different machine architectures: PC-DOS/MS-DOS, Apollo AEGIS, DEC VMS, Sun UNIX\*.

On a network with different types of computers you can access a single copy of a drawing from any machine.

## MORE NEW FEATURES.

Release 9 also offers you twenty additional text fonts from the industry standard Hershey library, B-spline curve generation, and a direct link to the newly released AutoShade™.

## RELEASE 9 = MORE POWER + EASIER ACCESS.

If you think CAD would boost your productivity, but you worry that a serious professional CAD package will take forever to learn, AutoCAD Release 9 is for you.

You'll be able to put its extraordinary capabilities to work faster than you ever thought possible.

AutoCAD is registered in the U.S. Patent and Trademark Office by Autodesk, Inc. AutoShade is a trademark of Autodesk, Inc. 2320 Marinship Way, Sausalito, CA 94965

## AUTOCAD THE STANDARD.

CAD is an essential productivity tool today, as essential as drafting boards and T-squares were yesterday.

With over 100,000 packages sold in seven languages around the world, AutoCAD is the CAD software of choice among architects, engineers and designers.

## CALL 800/445-5415 FOR DETAILS.

We'll put you in touch with an authorized dealer who will show you the unprecedented power and ease of use of AutoCAD Release 9.

Your dealer will also show you which graphics systems can support our new display capabilities.

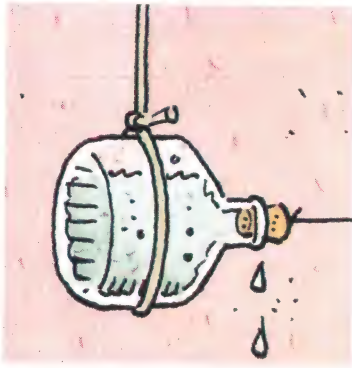
\*PC-DOS is a registered trademark of International Business Machines Corporation. MS-DOS is a registered trademark of Microsoft Corporation. Apollo AEGIS is a trademark of Apollo Computer, Incorporated. DEC and VMS are trademarks of Digital Equipment Corporation. Sun is a trademark of Sun Microsystems Incorporated. UNIX is a trademark of AT&T Bell Laboratories.



**AUTODESK, INC.**

*Tools for the golden age  
of engineering.*

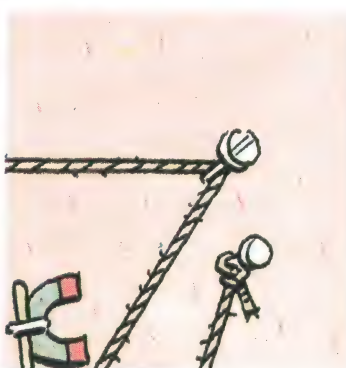
## MAKE THE RIGHT CONNECTIONS.



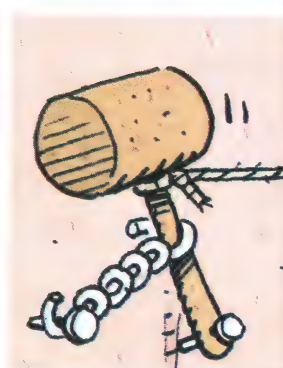
17



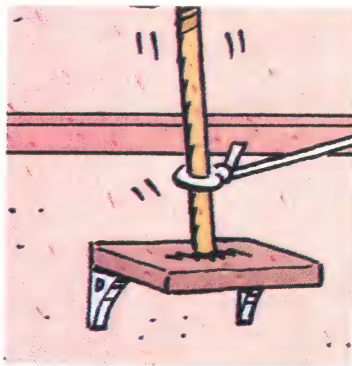
18



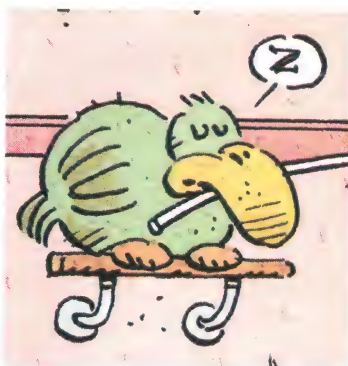
19



20



9



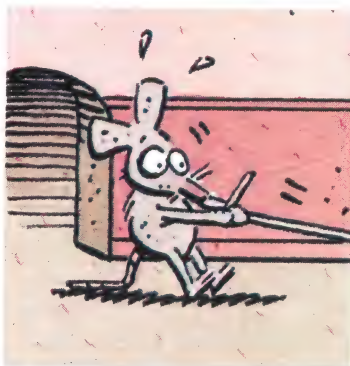
10



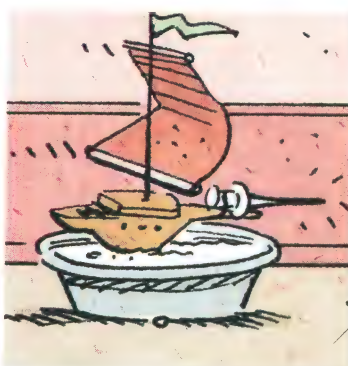
11



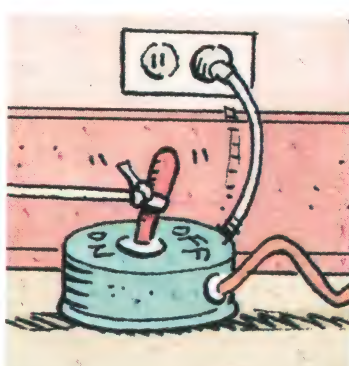
12



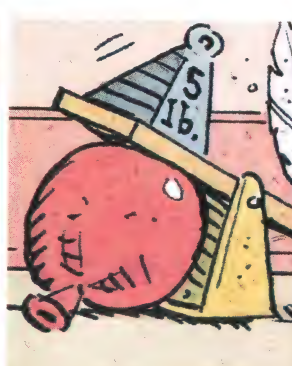
1



2



3

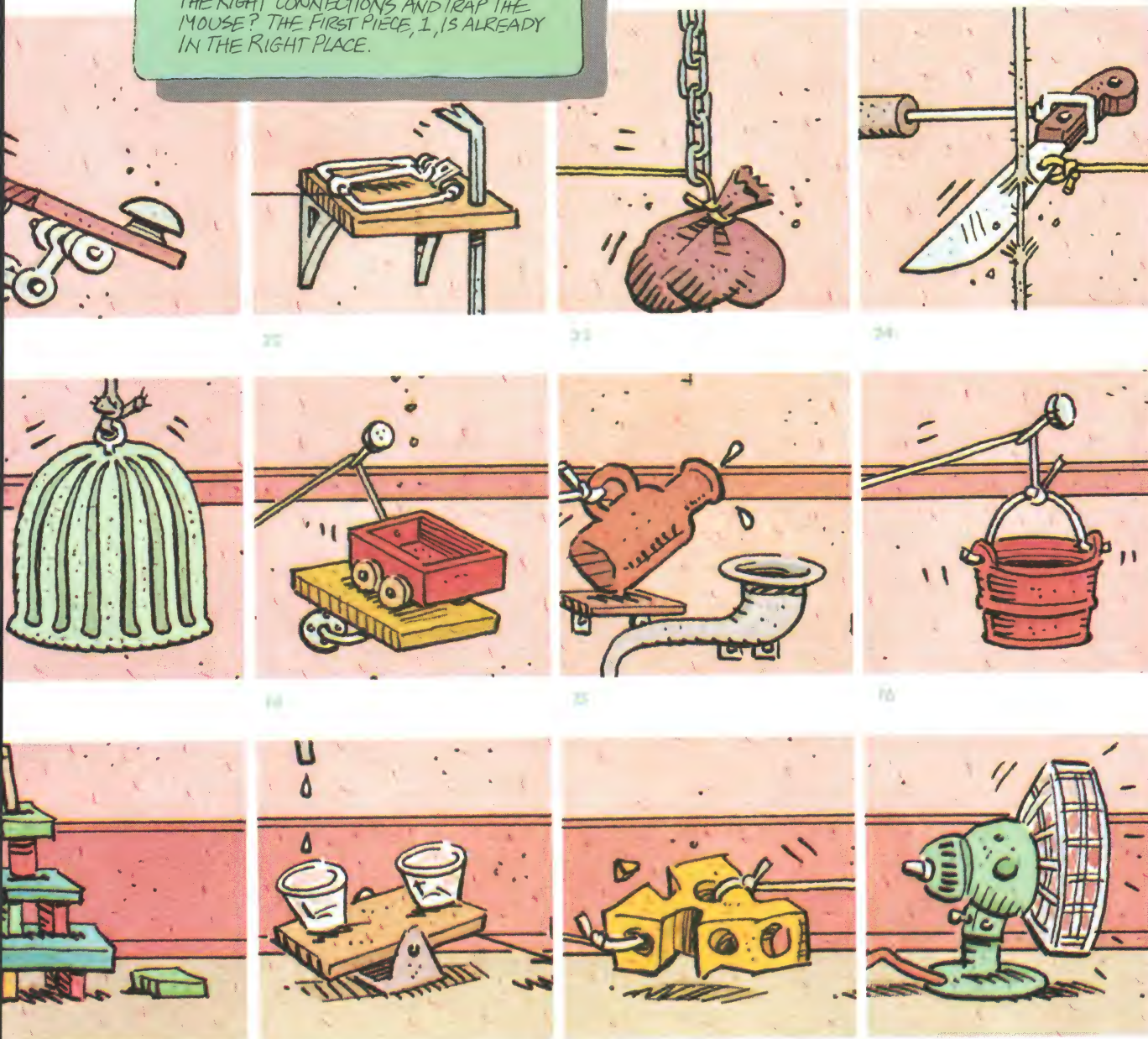


4

If you're already using the industry's highest throughput linear tester, the LTX Hi.T, or the most advanced digital tester, the LTX Trillium, or the industry-standard mixed-signal tester, the LTX Ninety (or all three for that matter), there's only one thing left to do: Successfully connect test floor engineering and manufacturing information to company decision makers. Build a better network, and the industry will beat a path to your door. For the test floor interconnection of LTX equipment as well as other hardware to the entire factory, the answer is EZ-NET™: a



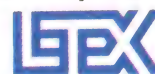
Q: EACH ROW OF THIS UNIQUE MOUSETRAP HAS BEEN SCRAMBLED. THE PARTS IN EACH ROW ALWAYS REMAIN IN THAT ROW. CAN YOU RETURN THEM TO THEIR PROPER POSITIONS SO THEY MAKE THE RIGHT CONNECTIONS AND TRAP THE MOUSE? THE FIRST PIECE, 1, IS ALREADY IN THE RIGHT PLACE.



GAMES MAGAZINE Copyright © 1986.

single source solution to a multi-source problem. EZ-NET is a compatible group of networking information products, designed to create an information and control solution custom-made for you. So the right people have the right information at their fingertips, to help turn raw data into money-making decisions.

If you'd like to develop an integrated tester environment that truly maximizes the strengths of your people and equipment, LTX can put it all together. We can also put together the mousetrap brain tester above. Just call your nearest LTX sales office.



TEST YOUR LIMITS

# Make the connection with Emerald.



Touch Terminal, CGA Monitor, RS232 Terminal and 26" Plasma Monitor (rear)

**EMERALD saves you time and money with complete systems, interfaces and controllers that let you connect your system to a flat panel display without altering or customizing existing circuits.**

As great as flat panel displays are, they have one major drawback. They don't easily connect to any existing CRT-based system. Until now you've had only two options: spend a lot of time and money engineering a product yourself, or buy a potentially overpriced or inadequate product.

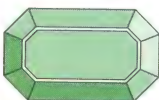
Emerald offers a better solution. You can purchase a high-performance unit from us, ready to connect. Emerald manufactures an array of products: terminals and monitors (some with touch input), sub-assemblies, and board level interfaces and controllers. Emerald supports all technologies: EL, Plasma, VF and LCD. For specialized, high-volume applications, we custom design anything from board level products to complete systems.

So, to make your connection easily and economically, talk to Emerald. We are the most experienced and diversified flat panel display people in the industry.

Here's a sample of what you can get, at prices you can afford.\*

• Terminals	\$1,595
• Touch Terminals	1,995
• Monitors	1,550
• LCD VT100 Terminals	1,095
• Subsystems	1,295
• Text and Graphics RS232	220
• RGB-EGA to 640x400	180
• RGB-CGA to 640x200	110

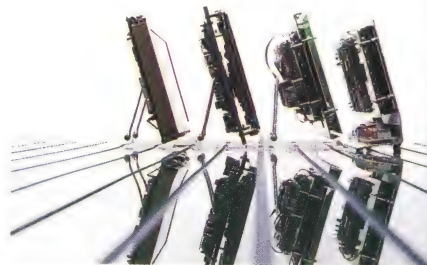
\*Based on the purchase of 1,000 units.



**EMERALD**

7324 S.W. Durham Rd.  
Portland, OR 97224  
(503) 620-6094  
FAX (503) 639-7932

LCD, Plasma, EL Touch and EL Modules



Interface and Controller Boards

## Raster printers profit from available technologies to suit diverse uses

Maury Wright, *Regional Editor*

Almost all computer applications today rely on hard-copy-output devices, and with the abundance of raster-printing technologies available, you can now match a raster printer with just about any application. Not only do you have a choice of monochrome- and color-graphics capabilities, you can spend as little as a few hundred dollars to as much as several thousand. Still and all, for the time being, printer-control languages and application software may ultimately dictate your choice.

Whether you're choosing a raster printer for yourself or whether you want to integrate one in a particular system, you have the same choice of technologies: dot matrix, laser, LED, LCS (liquid crystal shutter), ink jet, thermal transfer, and electrostatic—not to mention other, lesser-known types. When it comes time to decide on a technology, such factors as output quality, printing speed, and cost as well as software are important.

In terms of units sold, dot-matrix-impact types dominate the market. These printers offer such features as 300-cps print speeds, letter-quality-print emulation, graphics, plotter emulation—and even color printing—for less than \$1000. Some dot-matrix printers even sell for less than \$200. Dot-matrix units will continue to retain their popularity in many applications strictly because of their low cost.

### Laser prices are coming down

In the majority of applications, however, laser printers offer increased functions, and prices for entry-level versions have dropped to less than \$2000. Office Automation



*Ink-jet technology and 240-dot/in. resolution allow the Howtek Pixelmaster to print images on plain paper.*

Systems Inc (Oasys), for example, offers its 8-page/minute Laserpro Express for \$1895, and the 6-page/minute Laserline 6 from Okidata sells for \$1995. (Incidentally, the combined availability of near-letter-quality dot-matrix printers and low-cost laser printers has virtually eliminated the daisy-wheel printer market.)

Laser printers' advantages revolve primarily around their printing speed, output quality, and graphics capabilities. Models are available with 300×300-dot/in. resolution, and you can expect to see 400- and 600-dot/in. units within the next year. The quality of text possible with recently introduced laser printers far exceeds that of dot-matrix offerings.

The slowest laser printers print at speeds equal to the fastest dot-matrix units—and orders of magnitude faster than daisy-wheel printers. Nevertheless, you should beware

when considering laser printers' speed specs. Most manufacturers specify the theoretical maximum speed of a printer's engine. You may find that, in real life, your laser printer operates slower even on simple text-printing tasks. Printing complex graphics jobs can take several minutes per page.

Actually, choosing a laser printer for word-processing applications is a rather simple procedure. Most laser printers emulate popular dot-matrix and daisy-wheel printers and therefore you can drive them with virtually any text-oriented software package. Consequently, you should choose a printer for such text applications based on electromechanical design, ease of use, cost, and the output quality that your application demands.

The electromechanical, or engine, design is the factor most responsible for a printer's ease of use, speed, and printing quality, and it also

# THE RADIATION HARDENABLE SEMICONDUCTORS TO BEYOND 5 MEG RADS

### *Low-Noise, Précision, High-speed Operational Amplifier.*

Precision amplification of very low level, low frequency voltage inputs is enhanced by ultra-low input voltage noise.

Op-27 and Op-37 maintain high dc accuracy due to ultra-low offset voltage, offset voltage drift and input bias current.

#### **LS OP-27**

- Gain Bandwidth : 8Meg Hz
- Slew Rate : 2.8V/  $\mu$ S
- DIE SIZE : 1.44 x 2.57 mm, 3.62 sq. mm

#### **LS OP-37**

- Gain Bandwidth : 63Meg Hz
- Slew Rate : 17V/  $\mu$ S
- DIE SIZE : 1.44 x 2.57 mm, 3.62 sq. mm

### *Low Temperature Coefficient Precision 1,2 Volt Reference*

#### **LS 5010**

- Initial accuracy :  $\pm 4$ mV
- Ultra Low Tempco : 5ppm/  $^{\circ}$ C max
- DIE SIZE : 0.965 x 1.44 mm, 139 sq. mm.

# TECHNOLOGY UPDATE

influences cost. The majority (75% or maybe more) of the laser printers available use either a Ricoh or Canon engine. When evaluating a laser printer's engine, you have to evaluate characteristics such as its duty cycle, paper path, paper-output options, paper-feed options, and maintainability.

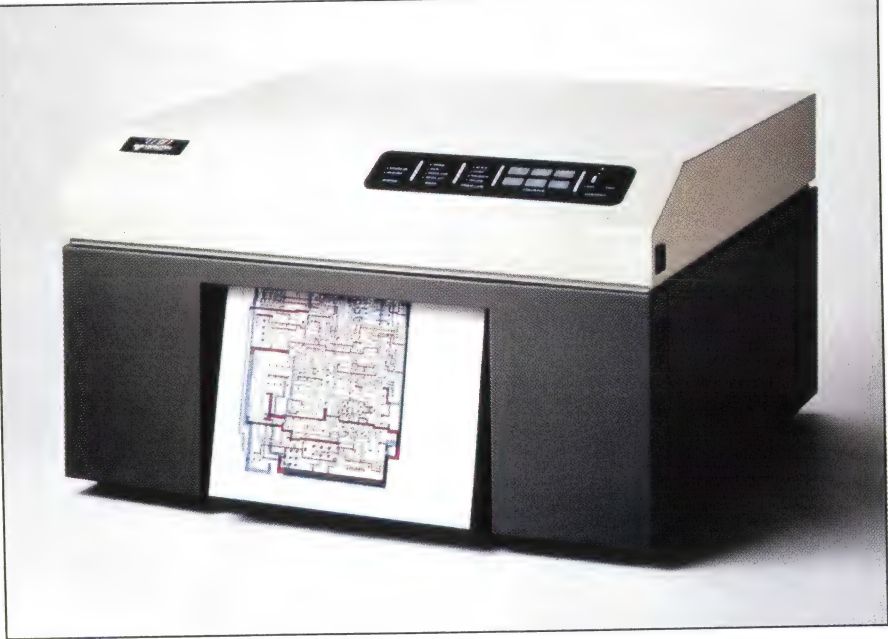
First, keeping your application foremost in mind, ascertain that the engine is rated to print the number of pages you require per month—not to mention its lifetime printing spec. Also, the straighter and simpler a printer's paper path, the less likely you'll be stuck with paper jams or wrinkled paper. Make sure the engine offers a face-down (colated) paper-output capability. Printers that handle envelopes without wrinkling them typically use a straight-through paper path for such hand-fed items.

Laser printers require different maintenance than traditional types of printers. For instance, you have to replace toner cartridges and drum units on a regular basis. Make sure that the installation of these consumables is straightforward. Some printer manufacturers promote the inexpensiveness of their consumables as a feature. Although toner and drum units do affect the cost of using a printer, these costs are negligible for most applications.

## LEDs and LCSs charge drum

Printers that use engines based on LED or LCS technology compete directly with laser printers for applications such as word processing and graphics, and in fact, some manufacturers call LED or LCS printers laser printers to avoid confusion. All three types use a similar printing technology. A light source alters the charge of a photosensitive drum. The drum attracts toner particles with an opposite charge. The drum then transfers the toner to the paper, and the printer fuses the toner and paper with heat.

Laser printers employ a laser source and a rotating mirror to



*Both electrostatic and thermal-transfer printers from Versatec target the CAE/CAD market for plotters.*

strobe the lines of an image onto the drum surface. LCS printers use a single light source and a linear array of LCS elements to transfer each line of an image to the drum. LED engines include an array of LED elements that alters the drum's charge.

A number of new LED and LCS printers are available that suit word-processing and monochrome-graphics applications. For instance, Data Technology offers the \$1995 6-page/minute Crystalprint Series II and the \$2495 8-page/minute Crystalprint VIII. Both employ LCS technology. Fujitsu recently introduced the RX7100 LED printer, which prints 5 pages/minute and sells for \$1160 (100).

Advocates of LED and LCS technology claim that engines for such printers cost less than laser engines. Laser-printer manufacturers argue that, today, the cost difference is less than \$50. The LED and LCS units do lend themselves to simpler engine repairs, however.

## Printer language guides choice

Printer technology notwithstanding, when choosing a printer for graphics applications such as desk-

top publishing, you have to consider the issue of software. Publishers of complex graphics packages can't support all the different printers available the way publishers of word-processing packages can. You'll be well-advised to choose a printer that emulates a de facto graphics printing standard.

More page-graphics application software supports the Hewlett-Packard Printer Control Language (PCL) than any other printer language, and HP holds a dominant share of the laser-printer market with its Laserjet family of printers. Moreover, the company developed PCL in levels, or layers, so that it could use the language in all its printer products. Simple dot-matrix printers only use the low levels of PCL; laser printers use the highest levels.

The 8-page/minute \$2595 Laserjet Series II printer is currently the mainstay of the Laserjet family. The standard model includes only 512k bytes of memory, but you can ask for an additional 1M-byte (\$495), 2M-byte (\$995), or 4M-byte (\$1995) board. The standard configuration isn't capable of full-page graphics output: You must add

# TECHNOLOGY UPDATE

memory to improve its graphics capabilities and to allow the machine to hold multiple fonts in memory.

Numerous manufacturers offer raster printers compatible with Laserjet Series II PCL (typically called Laserjet+ compatibility), but some are more compatible than others. In certain cases, you can simply test a particular printer's compatibility with the software package you wish to use, but such simple tests don't prove complete PCL compatibility. **Ref 1** contains some sample programs that are effective for testing compatibility. A printer that passes such tests will be more likely to work with any software package that supports the Laserjet Series II and its downloadable fonts.

As is true of the Laserjet units, PCL-compatible printers from other manufacturers also require extra memory to handle downloadable fonts and graphics. The Oasys Laserpro Express offers PCL compatibility, but not a downloadable-font feature. The company's \$2295 Laserpro Express Series II accepts downloadable fonts; you must purchase the \$2795 Laserpro Silver Express or the \$3695 Laserpro Gold Express to add full-page graphics capabilities.

Okidata's Laserline 6 comes with just 272k bytes of memory, and you can only expand it to 676k bytes. So, even though the Laserline 6 accepts downloadable fonts, it can't print a full page of graphics. Data Technology's Crystalprint VII includes 1.5M bytes of memory, but the Crystalprint Series II only includes 512k bytes (albeit expandable to 1.5M bytes). The Fujitsu RX7100 contains 640k bytes of memory, and the company plans to offer expansions for a total of 3M bytes.

## Postscript adds versatility

For some graphics applications, you may want to consider a printer with a higher-performance control language—the Postscript page-description language from Adobe Sys-



*An extended version of the manufacturer's PCL (printer control language) includes color commands to control the Paintjet printer from Hewlett-Packard.*

tems (Mountain View, CA), for example. Adobe developed the language and licenses it to printer manufacturers. Postscript provides software developers with a tool for creating, modifying, and printing graphical images. It also has a set of proprietary fonts and can scale those fonts to any size.

Typically the Postscript interpreter resides in the printer and offloads much of the graphics processing from the host. The cost of adding Postscript to a printer is approximately \$2000; it is the combination of royalties paid to Adobe and the added computing power required to run the language that results in the price premium.

Many graphics packages that take advantage of Postscript are emerging, and several printer manufacturers now offer Postscript-compatible printers. QMS and its subsidiary, The Laser Connection, both have Postscript-compatible printers available. The QMS-PS 810 has 2M bytes of memory and is compatible with both Postscript and PCL. Indeed, this \$5495 8-page/minute printer includes an Appletalk inter-

face in addition to the standard printer interfaces.

The Laser Connection sells the \$4995 PS Jet and the \$5495 PS Jet Plus, which include 1.5M and 2M bytes of memory, respectively. These printers offer essentially the same features as the QMS product. The Laser Connection also offers an add-on product that converts the Hewlett-Packard Laserjet Series II printer to a Postscript printer. The \$2495 kit includes a board that resides in a personal computer and a board that is installed in the printer. The company offers similar capabilities for other printers with Canon engines.

Several other printer companies have licensed Postscript for use in laser printers, including AST Research, NEC Information Systems, and Texas Instruments. Other companies will choose to acquire Postscript compatibility elsewhere.

Phoenix Technologies Ltd (Norwood, MA), for example, has announced its Page Printer Control System (PPCS), and Canon intends to use PPCS in a printer due out around midyear. Phoenix Techno-

# A STRIKING NEW COMBINATION OF SPEED, RESOLUTION, ACCURACY AND RECORD LENGTH!

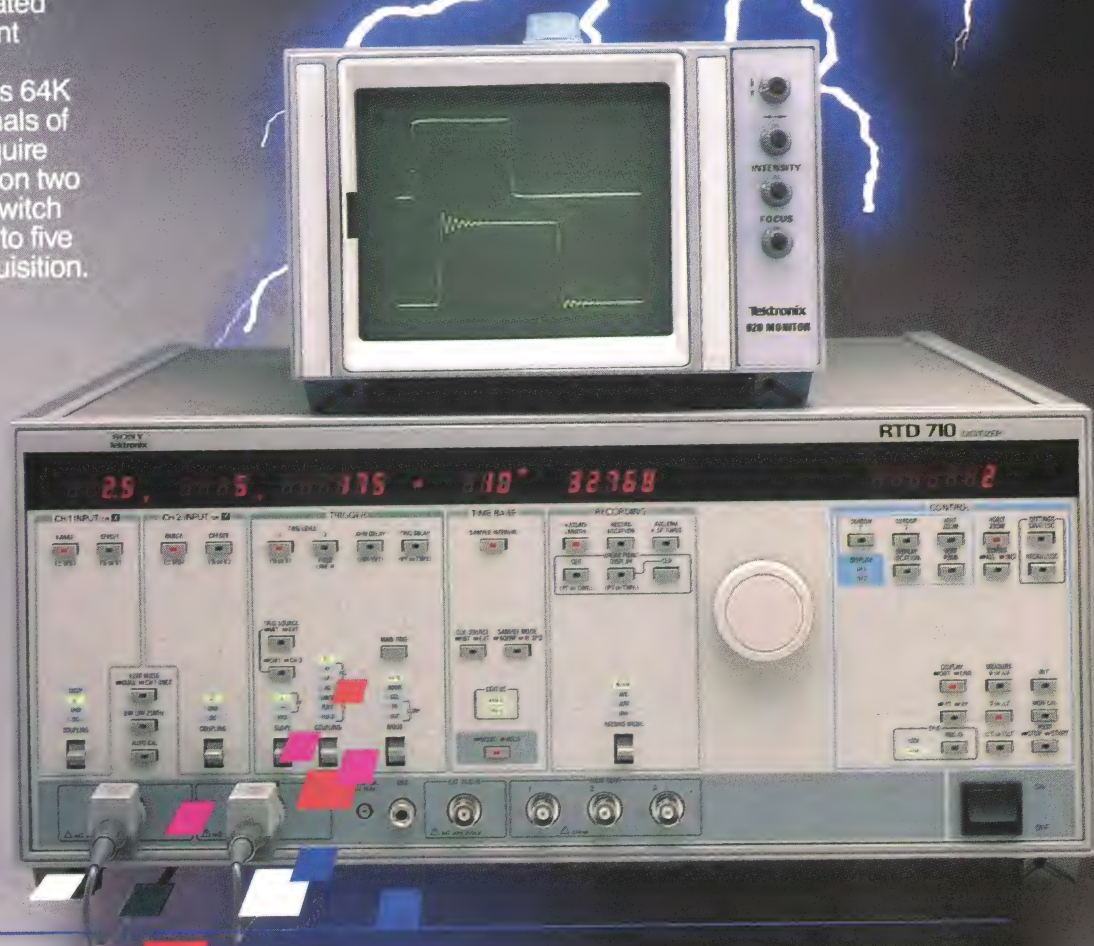
200 MS/s., 10-bit resolution, +.4% gain accuracy, and 64K record length: the best balance in high-resolution digitizers is clearly the new RTD 710 from Tektronix.

The RTD 710 lets you work with fast transients, from DC to 100 MHz, in standalone, semi-automated or fully automated test and measurement environments.

You can partition its 64K memory to store signals of different lengths. Acquire data simultaneously on two different channels. Switch sampling speeds up to five times in a single acquisition.

Add a TV triggering option for video applications. And choose from a variety of computer-based measurement packages.

Call 1-800-835-9433 for more information or to arrange a personal demonstration.



**Tektronix**  
COMMITTED TO EXCELLENCE

CIRCLE NO 81

# TECHNOLOGY UPDATE

logies cloned Postscript but of course had to use its own fonts and algorithms. Personal Computer Products Inc (San Diego, CA) has also introduced its Imagescript language, which emulates Postscript. Oasys has announced plans to offer a Postscript clone, developed in-house, as an option on its Express printers.

As you can surmise, the market for monochrome desktop graphics is booming, thanks to the combination of available graphics software, reasonably priced printer hardware, and standard printer-control languages. This is not yet the case for the color-graphics market, although color printers are emerging that will eventually bring color graphics to the desktop. Soon companies will even offer color laser printers. Still, no standards yet exist for color desktop graphics. Adobe plans on adding color to Postscript, but products may be a year away. In addition, manipulating color images requires more computing power and better software than do monochrome applications.

Hewlett-Packard currently offers



*The 3M-byte memory capacity of the Oasys Laserpro Gold Express provides room for downloadable fonts and full-page bit-image graphics.*

its Paintjet printer for \$1395. The printer employs ink-jet technology, produces 180×180-dot/in. resolution, and can also output near-let-

ter-quality text at 167 cps. Hewlett-Packard added extensions to PCL to control the Paintjet, and the printer primarily targets applications such

## For more information . . .

For more information on the raster printers discussed in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

**AST Research Inc**  
2121 Alton Ave  
Irvine, CA 92714  
(714) 863-1333  
TLX 753699  
Circle No 670

**Canon USA Inc**  
1 Canon Plaza  
Lake Success, NY 11042  
(516) 488-6700  
Circle No 671

**Data Technology Corp**  
2551 Walsh Ave  
Santa Clara, CA 95051  
(408) 727-8899  
Circle No 672

**Fujitsu America Inc**  
3055 Orchard Dr  
San Jose, CA 95134  
(408) 432-1300  
TLX 176207  
Circle No 673

**Hewlett-Packard Co**  
1820 Embarcadero Rd  
Palo Alto, CA 94303  
Phone local office  
Circle No 674

**Howtek Inc**  
21 Park Ave  
Hudson, NH 03051  
(603) 882-5200  
Circle No 675

**The Laser Connection**  
7852 Schillinger Park W  
Mobile, AL 36608  
(205) 633-7223  
Circle No 676

**NEC Information Systems Inc**  
1414 Massachusetts Ave  
Boxborough, MA 01719  
(617) 264-8000  
Circle No 677

**Office Automation Systems Inc (Oasys)**  
8352 Clairemont Mesa Blvd  
San Diego, CA 92111  
(619) 576-9500  
Circle No 678

**Okidata Corp**  
532 Fellowship Rd  
Mount Laurel, NJ 08054  
(800) 654-3282  
Circle No 679

**Ricoh Corp**  
155 Passaic Ave  
Fairfield, NJ 07006  
(201) 882-2000  
TLX 752930  
Circle No 680

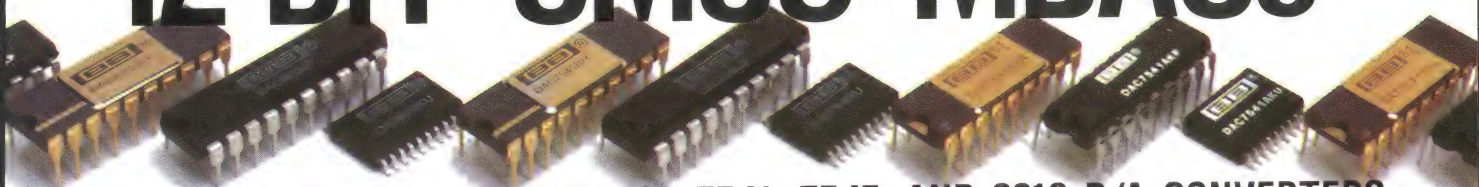
**QMS Inc**  
1 Magnum Pass  
Mobile, AL 36618  
(205) 633-4300  
TLX 266013  
Circle No 681

**Tektronix Inc**  
Box 1000, MS 63-447  
Wilsonville, OR 97070  
(503) 235-7202  
Circle No 682

**Texas Instruments**  
Box 809063  
Dallas, TX 75380  
(800) 527-3500  
Circle No 683

**Versatec**  
2710 Walsh Ave  
Santa Clara, CA 95051  
(408) 988-2800  
TWX 910-338-0243  
Circle No 684

# NEW FROM BURR-BROWN FIRST QUALITY SECOND-SOURCE 12-BIT CMOS MDACs



30+ LOW COST REPLACEMENTS FOR 7541, 7545, AND 8012 D/A CONVERTERS

Model	Description/Features	Max Relative Accuracy (LSB)	Max Gain Error (LSB) $V_{DD} = +5V$	Temperature Range (°C)	Package Type
DAC7541AJP	4-quadrant multiplying • Latch-up resistant • Low cost • Replace 7521, 7541, 7541A DACs	$\pm 1$	$\pm 6$	0/+70	Plastic DIP
AKP		$\pm 1/2$	$\pm 1$	0/+70	Plastic DIP
AJU		$\pm 1$	$\pm 6$	0/+70	Plastic SOIC
AKU		$\pm 1/2$	$\pm 1$	0/+70	Plastic SOIC
AAH		$\pm 1$	$\pm 6$	-25/+85	Ceramic DIP
ABH		$\pm 1/2$	$\pm 1$	-25/+85	Ceramic DIP
ASH		$\pm 1$	$\pm 6$	-55/+125	Ceramic DIP
ATH		$\pm 1/2$	$\pm 1$	-55/+125	Ceramic DIP
DAC7545JP	4-quadrant multiplying • Buffered inputs • Low cost • Replace 7545 DACs	$\pm 2$	$\pm 20$	0/+70	Plastic DIP
KP		$\pm 1$	$\pm 10$	0/+70	Plastic DIP
LP		$\pm 1/2$	$\pm 5$	0/+70	Plastic DIP
GLP		$\pm 1/2$	$\pm 1$	0/+70	Plastic DIP
JU		$\pm 2$	$\pm 20$	0/+70	Plastic SOIC
KU		$\pm 1$	$\pm 10$	0/+70	Plastic SOIC
LU		$\pm 1/2$	$\pm 5$	0/+70	Plastic SOIC
GLU		$\pm 1/2$	$\pm 1$	0/+70	Plastic SOIC
AH		$\pm 2$	$\pm 20$	-25/+85	Ceramic DIP
BH		$\pm 1$	$\pm 10$	-25/+85	Ceramic DIP
CH		$\pm 1/2$	$\pm 5$	-25/+85	Ceramic DIP
GCH		$\pm 1/2$	$\pm 1$	-25/+85	Ceramic DIP
SH		$\pm 2$	$\pm 20$	-55/+125	Ceramic DIP
TH		$\pm 1$	$\pm 10$	-55/+125	Ceramic DIP
UH		$\pm 1/2$	$\pm 5$	-55/+125	Ceramic DIP
GUH		$\pm 1/2$	$\pm 1$	-55/+125	Ceramic DIP
DAC8012JP	4-quadrant multiplying • Data readback • No protection Schottky needed • Low cost • Replace 8012 DACs	$\pm 1$	$\pm 3$	0/+70	Plastic DIP
KP		$\pm 1/2$	$\pm 1$	0/+70	Plastic DIP
JU		$\pm 1$	$\pm 3$	0/+70	Plastic SOIC
KU		$\pm 1/2$	$\pm 1$	0/+70	Plastic SOIC
AH		$\pm 1$	$\pm 3$	-25/+85	Ceramic DIP
BH		$\pm 1/2$	$\pm 1$	-25/+85	Ceramic DIP
SH		$\pm 1$	$\pm 3$	-55/+125	Ceramic DIP
TH		$\pm 1/2$	$\pm 1$	-55/+125	Ceramic DIP

Now you can get your CMOS MDAC solutions from one source—Burr-Brown. And they're backed by 30+ years of quality linear design and manufacturing experience, more than any other supplier.

#### Consider these features:

- CMOS processing yields high performance at low power;
- pin-for-pin replacements for industry standard parts;

- choice of ceramic, plastic, and SOIC packages;
- guaranteed 12-bit monotonicity over temp range;
- single +5V to +15V supply, 30mW max;
- only second-source for latched "8012" devices, with data read-back feature;
- superior design gives you extra protection against input "latch-up" problems;
- 10%-20% lower prices.

We've got all the low power, low cost 12-bit CMOS MDACs you need. If we don't make them first, we make them better. Call your sales rep or Applications Engineering, 602/746-1111, for complete information and samples. Burr-Brown Corp., PO Box 11400, Tucson, AZ 85734.



# TECHNOLOGY UPDATE

as spreadsheet-program-generated charts. Although you can use plain paper with the Paintjet, the company recommends special paper or transparency media for best results.

Howtek is another vendor with a color printer for sale that uses ink-jet technology. The Pixelmaster is capable of generating color-page graphics comparable to those of monochrome laser printers. It mixes text and color graphics on a page at a resolution of 240 dots/in.

Furthermore, this printer prints on plain paper. The unit includes compatibility with PCL and extensions for color output. Although its resolution and print quality are sufficient for color desktop publishing, you may have a hard time finding a software package to drive it. An IBM PC/AT-class host would be very slow in generating a color-graphics image without help from dedicated hardware. The printer costs \$4500 with 512k bytes of memory; a 2.5M-byte version sells for \$5700.

Tektronix offers a thermal-transfer color-graphics printer that prints 300 dots/in. The 4693D can produce high-quality pages of graphics, but requires the use of coated paper. Tektronix presently offers the product with a card that interfaces to the Apple Macintosh II Nubus; the Macintosh II version with 4M bytes of RAM costs \$7995. The Tektronix printer suffers from the same lack of software and dedicated hardware as the Howtek product.

The Colorgrafix 100 printer from QMS is probably the closest to providing the computer power necessary for processing color images. QMS sells the \$16,995 printer with a 2-board dedicated controller. The boards fit in an IBM PC/AT or compatible and include a TI TMS 34010 graphics processor. The thermal-transfer printer's resolution is 300×300 dots/in. The controller's native language is an extension of the Direct Graphics Interface Specification (DGIS).



*The LED engine that Fujitsu uses in its 5-page/minute RX7100 proves to be a low-cost alternative to a laser-based engine.*

QMS has also signed the first licensing agreement for a color version of Adobe's Postscript language. QMS will introduce a color Postscript-based printer early this year and plans to ship it in the second half.

Besides word-processing and desktop publishing, you can also make use of some of these monochrome and color raster printers in CAE/CAD applications. For example, the monochrome page printers from both Oasys and QMS, as well as Howtek's color Pixelmaster, include support for Hewlett-Packard's plotter control language, HP-GL.

Oasys has recently introduced the 22-page/minute Laserpro 2200, which prints on 11×17-in. paper, for \$16,500. Don't expect laser technology to allow printing on paper much wider than 11 inches. The laser beam becomes distorted when aimed at the edges of the printer drum. LED or LCS printers, however, may continue to expand in terms of paper-width-printing capabilities.

## **Electrostatic plotter for CAD**

Electrostatic plotters are also useful in CAE/CAD applications. Electrostatic devices essentially em-

ploy a raster-printing technology, but most people think of them primarily as plotters. Such plotters are popular because they print many orders of magnitude faster than pen plotters. In an electrostatic device, coated paper passes under an electrostatic head. The electrostatic head consists of a linear array of wire nibs.

The wire nibs in the electrostatic head place a charge on the coated paper. The paper passes through a toner bath and then a fusing process. The wire nibs in the electrostatic head determine the resolution. Typically, electrostatic plotters are capable of 400-dot/in. resolution.

Versatec's electrostatic plotters cover a broad range. The V-80 family plots on 11-in.-wide paper, and Series 7000 plotters plot on 22- or 44-in.-wide paper. Moreover, the company also offers electrostatic devices with color capability. These plotters use a single electrostatic head and four toner stations to produce color with four passes made on each plot. The 2500 Series produces color on 11-in. paper, and the 3000 Series is compatible with 22- and 44-in. paper.

Because electrostatic plotters

# When old ideas need new solutions



## Omron responds.

**O**mron's innovative design capabilities, coupled with their wide variety of relays, switches and photomicrosensors, give you the ability to improve upon your present product designs and make tomorrow's technologies more productive.

From the automotive industry to office automation, Omron's broad product line capabilities are bringing innovative products to life. Industrial robotics, bank teller machines, vending machines, security systems, automotive safety devices and computer systems are just a few of the thousands of products in which



Omron components are employed.

Backing up Omron's full-line of components is the security you'll feel in knowing that behind each product is our "zero defects" quality. Quality built on years of experience, and a desire to respond to customer design needs for product innovation.

Let one of our nationwide network of distributors accommodate your relay, switch or photomicrosensor needs quickly and reliably.

Call Omron toll free.

**1-800-62-OMRON**

**OMRON®**  
Responsive Innovation

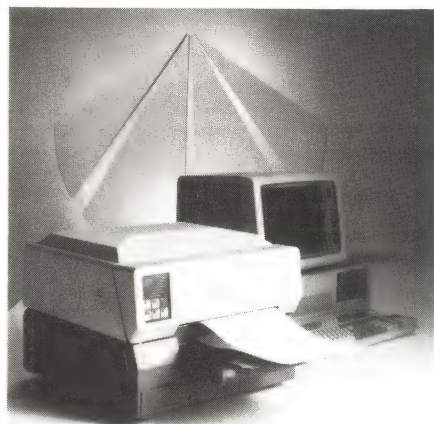
**OMRON ELECTRONICS, INC.**  
Consumer and Commercial Division  
One East Commerce Drive  
Schaumburg, Illinois 60173

# Looking for a job doesn't have to be one.

EDN's Career Opportunities  
section keeps you informed  
of current job openings  
from coast-to-coast

**TURN TO  
PAGE** **276**

## UPDATE



*Liquid-Crystal-Shutter (LCS) technology charges the photosensitive drum in Data Technology's Crystalprint VIII page printer.*

print raster data but often function in a vector world, Versatec offers a number of printer-control options. The company sells stand-alone rasterizing controllers, controllers that fit into a host such as a VAX or an IBM PC/AT, and controllers embedded in certain plotter models. Prices range from \$8000 for an 11-in. monochrome unit to \$52,000 for an E-size color unit that includes a rasterizing controller.

Rounding out its raster-printer offerings, Versatec has thermal-transfer color plotters for sale. The 2700 Series handles 11-in. paper. Typical configurations cost under \$9000. Although Versatec targets the 2700 Series for plotter applications, you can conceivably use these printers in other graphics applications.

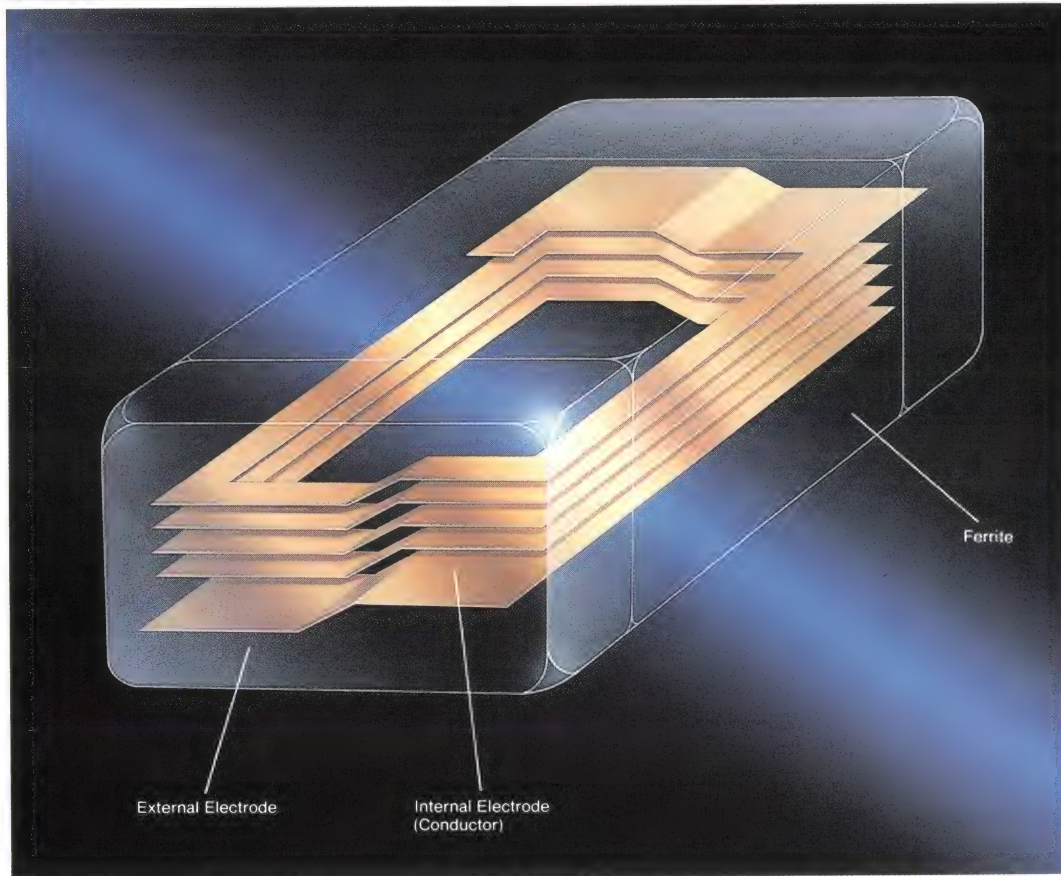
**EDN**

### Reference

1. McCown, R, and H Clark, "Laser Metrics," *PC Tech Journal*, September 1987, pg 74.

Article Interest Quotient  
(Circle One)

High 512 Medium 513 Low 514



## TDK Multilayer and Integration Technology Stands at the Leading Edge with TDK Multilayer Chip Inductors.

For the first time ever, inductors can be made without actual winding. Consider TDK Multilayer Chip Inductors. Thanks to TDK, they eliminate the problems of high density circuit boards.

Multilayer surface mount devices from TDK include ceramic chip capacitor networks, chip band pass filters and chip LC traps that require both designs and manufacturing technology of a sophisticated nature. Furthermore, TDK is making significant progress toward "super multilayer" and high circuits integration.

TDK technology ranges from raw materials to finished multilayer chip components to automatic mounting equipment, namely, our Avimount series. We strive to meet the requirements of the industry for high quality, high performance chip components. And we're striving to achieve total surface mount technology from start to finish.

When it comes to SMT, come to TDK.

TDK Surface Mount Technology—At Your Service.



TDK CORPORATION OF AMERICA HEAD OFFICE 4711 West Golf Road, Skokie, IL 60076, U.S.A. Phone: (312) 679-8200 CHICAGO REGIONAL OFFICE Phone: (312) 679-8200 INDIANAPOLIS REGIONAL OFFICE Phone: (317) 872-0370 NEW YORK REGIONAL OFFICE Phone: (516) 625-0100 LOS ANGELES REGIONAL OFFICE Phone: (213) 539-6631 DETROIT DISTRICT OFFICE Phone: (313) 353-9393 NEW JERSEY DISTRICT OFFICE Phone: (201) 736-0023 HUNTSVILLE DISTRICT OFFICE Phone: (205) 539-4551 GREENSBORO DISTRICT OFFICE Phone: (919) 292-0012 DALLAS DISTRICT OFFICE Phone: (214) 506-9800 SAN FRANCISCO DISTRICT OFFICE Phone: (408) 437-9585 TDK CORPORATION, TOKYO, JAPAN.

### Multilayer Ceramic Chip Capacitor

**C1608** (CC0603)  
C: 0.5 ~ 22,000pF  
**C2012** (CC0805)  
C: 0.5 ~ 100,000pF  
**C3216** (CC1206)  
C: 0.5 ~ 220,000pF  
**C3225** (CC1210)  
C: 750 ~ 470,000pF  
**C4532** (CC1812)  
C: 2,400pF ~ 1μF  
**C5650** (CC2220)  
C: 5,100pF ~ 1.5μF

### Leadless Inductor (Wound Chip Inductor)

**NL322522**  
L: 0.01 ~ 220μH  
**NL453232**  
L: 1.0 ~ 1,000μH  
**NL565050**  
L: 1,200 ~ 10,000μH  
**NLF453232**  
L: 1.0 ~ 1,000μH  
(Shielded Inductor)

### Multilayer Chip Capacitor Network

**MCN7575**  
TC: CH, 1 ~ 100pF  
(10 capacitors)  
SL, 10 ~ 1,000pF  
(10 capacitors)  
Class II,  
100 ~ 470,000pF  
(10 capacitors)

### Leadless LC Trap (Wound Chip LC Trap)

**NLT4532**  
F: 630kHz ~ 13MHz  
Tolerance: ±2%  
Attenuation: 20dB min.

### Multilayer Ceramic Chip Capacitor (High Frequency, Low Loss)

**FC1414**  
C: 0.5 ~ 3,300pF  
**FC2828**  
C: 0.5 ~ 22,000pF  
**FR1414**  
C: 0.5 ~ 3,300pF  
**FR2828**  
C: 0.5 ~ 22,000pF

### Leadless EMI Filter (Wound Chip EMI Filter)

**NLL4532**  
C: 33pF ~ 100,000pF  
L: 1μH ~ 220μH

### Multilayer Chip Inductor

**MLF3216**  
L: 0.047 ~ 33μH  
**MLF3225**  
L: 39 ~ 220μH

### Ferrite Chip Bead

**CB201209**  
Z<sub>0</sub>: 7, 10, 11n  
**CB321611**  
Z<sub>0</sub>: 19, 26, 31n  
**CB322513**  
Z<sub>0</sub>: 31, 52, 80n  
**CB453215**  
Z<sub>0</sub>: 70, 120, 125n

### Multilayer Chip LC Trap

**MXT4532**  
F: 10 ~ 2%

### NTC Chip Thermistor

**NTC CS3216**  
R typical:  
1.0 ~ 150kΩ at 25°C  
Temp. Range:  
-25 to +85°C

### Multilayer Chip IFT

**MIA4532**  
F: 455, 459, 464kHz  
**MIF4532**  
F: 10.7MHz

### SM Active Delay Line

**FDL**  
Delay time:  
20 ~ 75 nsec.

### Multilayer Chip Transformer

**MTT4532**  
L: 10 ~ 200μH

### SM Transformer/ Inductor

**EE5**  
**ER9.5**  
**ER11**  
**T2**  
A variety of  
characteristics are  
available.  
Please specify when  
ordering.

### Multilayer Chip LC Filter

**MXF4532H**  
HPF (Tuner)  
**MXF4532B**  
BPF (FM radio)  
**MXB5050B**  
BPF (VCR)  
**MXB5050L**  
LPF (VCR)  
**MXB5050D**  
Delay Line (VCR)  
A variety of  
characteristics are  
available.  
Please specify when  
ordering.

### SM Step-up Inductor (Piezoelectric Buzzer)

**OL3.3 x 1.6**  
**OL3.3 x 2.1**  
Inductance values are  
representative,  
please specify value  
when ordering.

# MILITARY 16-BIT A/D's FIRST IN THEIR CLASS

MIL-STD-1772 CERTIFIED

MN5295/MN5290 & MN6290

High Speed:

MN5295: 17 $\mu$ sec Max. Conversion Time

MN5290: 40 $\mu$ sec Max. Conversion Time

MN6290: 20kHz Min. Sampling Rate

Small 32-Pin Double-Wide DIP

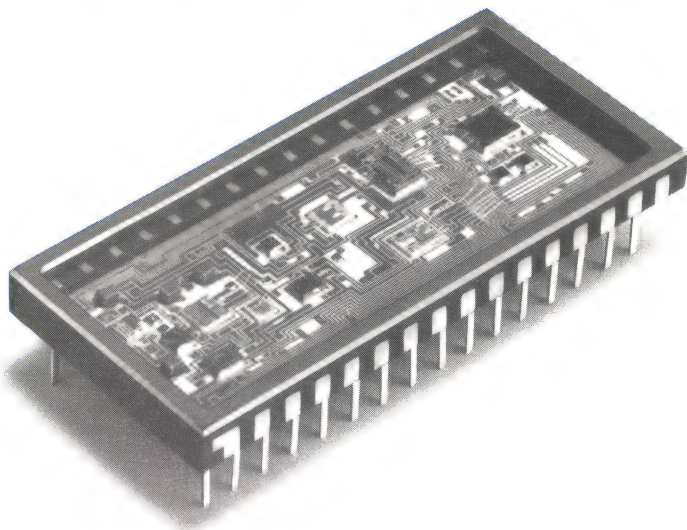
14-Bit "No Missing Codes"

-55°C to +125°C Operation

MIL-STD-883 Screening

In the two speed classes of 16-bit A/D's that have emerged, only one supplier designs its devices to meet all of your military and aerospace requirements: Micro Networks.

In the high-speed (15-20 $\mu$ sec) class, our MN5295/96 are the fastest (17 $\mu$ sec), smallest (by 31%), and *only* devices to offer -55°C to +125°C operation and MIL-STD-883 screening.



In the general-purpose (40-50 $\mu$ sec) class, our MN5290/91 offer these same advantages; while our MN6290/91 add an internal T/H, plus FFT testing for improved performance, ease of specification, and significant space savings.

And most critical to your designs, these are the *only* devices that operate over the extended military temperature range with full military screening.

## MN5295/MN5296

The newest in our expanding line of high-performance, military, 16-bit A/D's are at the top of their class.

**Fastest Conversion Time:**

17 $\mu$ sec Max. (16 Bits)

**Smallest Package by 31%:**

Double vs. Triple DIP

**Widest Temperature Range:**

- 55°C to +125°C

Only Devices Available with 883 Screening

In the top speed class, our MN5295/96 excel, providing outstanding 16-bit performance in a DIP package that is fully 31% smaller than any competitor's. No other supplier can meet your requirements for high-speed, high-resolution, military A/D's. When your design demands the best, demand Micro Networks MN5295/96.

## MN5290/MN5291

They're the best in their speed class of workhorse 16-bit A/D's. Specify them for all your applications that don't require the added performance of our MN5295/96.

**Fastest Conversion Time in Their Class:**

40 $\mu$ sec Max.

**Smallest Package by 31%:**

Double vs. Triple DIP

**Widest Temperature Range:**

- 55°C to +125°C

Only Devices Available with 883 Screening

Like our MN5295/96, our MN5290/91 A/D's are ideal for any design where you need *true* 14 or 13-bit performance over an extended temperature range. These devices were the first 16-bit military A/D's. Since their introduction, their broad acceptance and proven performance have made them industry standards.

## MN6290/MN6291

In a class by themselves, these FFT-tested sampling A/D's are ideal for traditional data acquisition and DSP applications.

**Single Package Sampling A/D**

**High Resolution/Sampling Rate:**

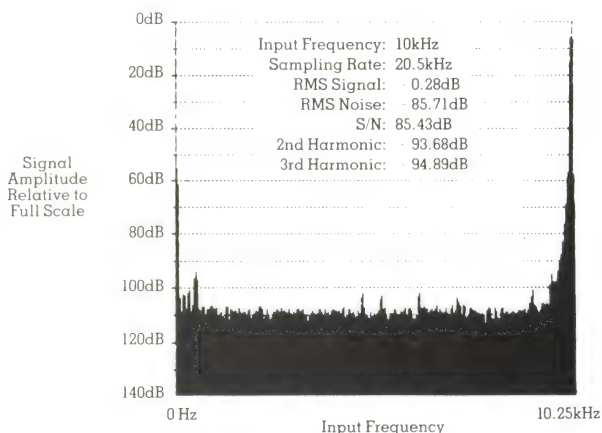
16 Bits @ 20kHz

**Signal-to-Noise Ratio: 84dB**

**Harmonics: - 88dB**

**Temperature Range: - 55°C to +125°C**

Available with MIL-STD-883 Screening



These devices eliminate the hassle of evaluating T/H specs that are difficult to understand and often don't relate.

For more detailed information, send for our comprehensive data sheets. For rapid response, call Russ Mullet at Ext. 208.

Micro Networks  
324 Clark Street  
Worcester, Massachusetts 01606  
(617) 852-5400

Micro Networks  
Advancing Data Conversion  
Technology

 **Micro Networks**  
A DIVISION OF **UNITRODE** CORPORATION

Regional Sales Offices: Worcester, MA (617) 852-5400; Dallas, TX (214) 991-8566; Santa Ana, CA (714) 261-5044.

# Hitachi MOS Memory Leadership Has Been Earned

The stag faces constant challenges from aspiring leaders of his herd. He maintains his leadership only by winning those battles—over and over again. Similarly, in the highly competitive MOS memory market, leadership must be earned ... not just claimed.

Hitachi's MOS memory leadership is well documented. For example:

1983 Hitachi is ranked the number one CMOS RAM manufacturer by engineers in *Electronic Design's* Audit of Brand Recognition.

1984 Hitachi again is rated the leading CMOS RAM manufacturer in *Electronic Design's* study.

1985 Hitachi again is rated number one in CMOS RAMs, in *ED's* Brand Recognition Study.

1986 Hitachi is the first manufacturer that purchasing agents consider when buying CMOS RAMs, as reported by *Electronic Buyers' News*, Buyers' Preference Study.

1986 Hitachi rated the most preferred CMOS RAM vendor in *EBN's* Japanese Semiconductor Manufacturers' Benchmark Study. First in quality, customer service, technical assistance, trust, ease of doing business ... and first in eight additional categories.

Marketplace recognition has been building over the years. This is due, in part, to our uncompromising QA programs, which have given our memory products a legendary reputation for quality and reliability. Our long-range investment in production technology is also important to our customers. It means that our products are in constant, dependable supply.

# Supremacy Achieved



*Hitachi's technology pushes MOS memory to new levels of performance.* The new HM62256 is the latest achievement. At 85ns, it's the fastest 32Kx8 SRAM you can buy, yet it draws only 40mW power. And, you can choose either a standard 28-pin DIP, or Hitachi's new surface mount SOP (Small Outline Package). This packaging innovation permits double-sided surface mounting for board densities five times greater than standard DIPs... another Hitachi plus.

So, the next time someone claims they're "number one" in MOS memories, consider the facts. If you're like the survey participants mentioned above, you'll call Hitachi first. Contact us through your local Hitachi Sales Representative or Distributor Sales Office today.

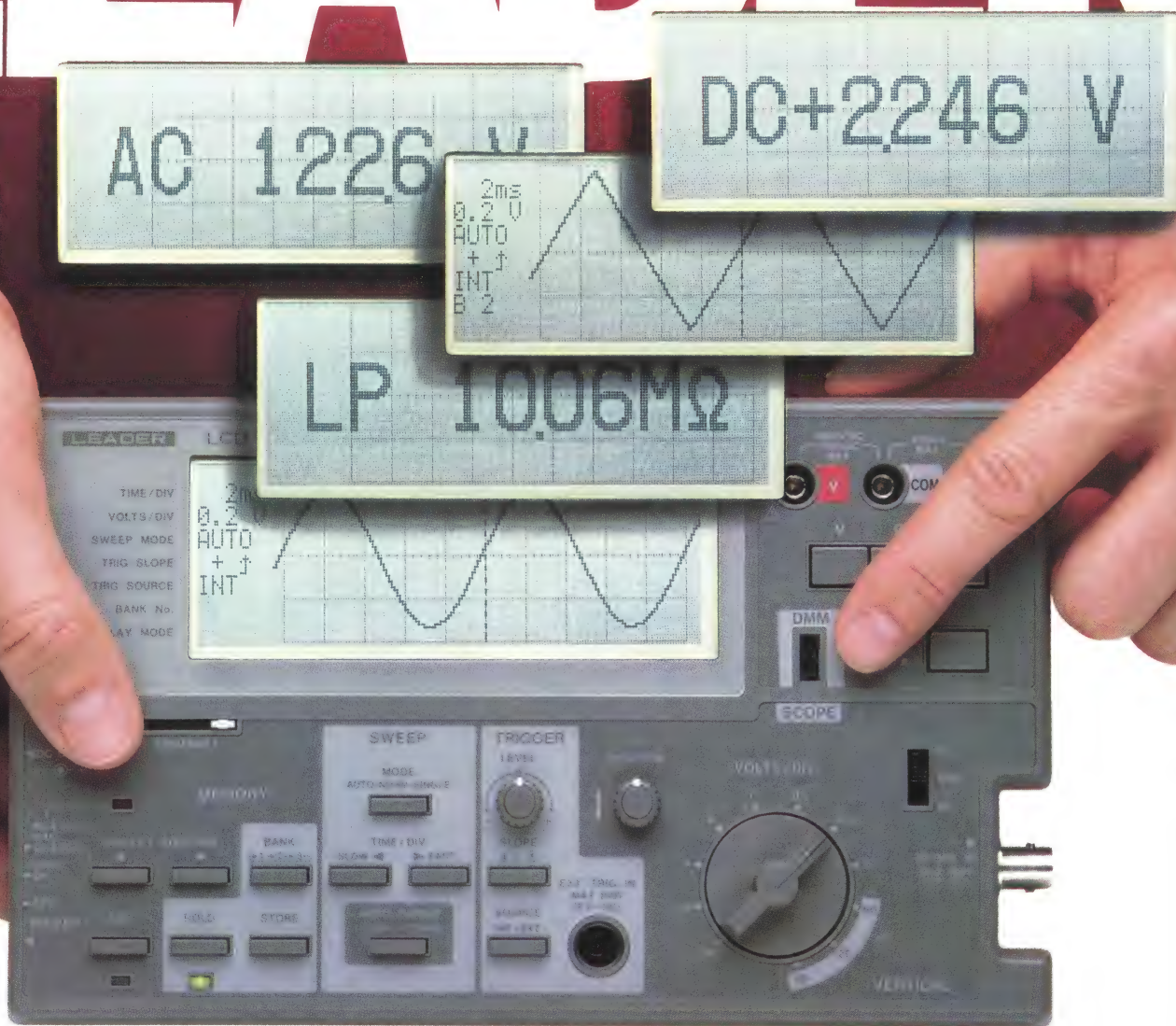
***Fast Action:*** To obtain product literature immediately, CALL TOLL FREE, 1-800-842-9000, Ext. 6809. Ask for literature number R16.

**Hitachi America, Ltd.**  
Semiconductor and IC Division  
2210 O'Toole Avenue, San Jose, CA 95131  
Telephone 1-408/435-8300



*We make things possible*





# Portable Problem Solver

## Ultra-compact Digital Storage Oscilloscope-Multimeter.

Easily carried in a tool kit or attache case—powered by batteries or supplied ac adaptor—this 2-in-1 lightweight is always ready for hand-held action.

## Multi-function, 200-kHz DSO.

Just flip the switch from DMM to SCOPE and the performance of a professional Digital Storage Oscilloscope is at your fingertips. Lets you capture and analyze single-shot and very slow phenomena. Stores up to three waveforms, and has such top-of-the-line features as auto-ranging time base setting, pre-trigger, roll mode, and on-screen readout of setting conditions. Low-power indicator

alerts you when batteries need recharging, while a separate back-up system protects memory.

## Full-function, 3½-digit DMM.

Precise measurement of ac/dc voltage, current and resistance is easy to see on the large, high-contrast, display. Automatically selects range which provides greatest accuracy and resolution.

## Perfect for many applications.

LCD-100 is a unique combination instrument that can confirm that its DMM is measuring a desired signal. Better by far than a DMM alone... more useful in the field than any benchtop DSO in this bandwidth, LCD-100 is ideal for servic-

ing a broad range of electromechanical, electrical and electronic systems.

Call toll-free  
**1-800-645-5104**  
In NY State  
**(516) 231-6900**

Ask for an evaluation unit, our latest Catalog, more information, or the name of your "Select" Leader Distributor.

For professionals  
who know  
the difference.  
**LEADER**  
Instruments Corporation

380 Oser Avenue, Hauppauge, New York 11788  
Regional Offices:  
Chicago, Dallas, Los Angeles, Boston, Atlanta  
In Canada call Omnitronix Ltd. (416) 828-6221

## Wideband 500-kHz to 1-GHz hybrid amplifier includes internal decoupling capacitors

The LH4200 is a general-purpose 500-kHz to 1-GHz amplifier that includes internal decoupling capacitors to simplify its use. This device has been demonstrated to work even with extremely long power-supply leads. The only extra decoupling it requires is an electrolytic capacitor to guard against low-frequency oscillations.

The amplifier's input stage is a dual-gate GaAs FET, which provides low input capacitance and high transconductance. The dual-gate structure accepts the signal on input 1. Input 2 controls the gain of the amplifier. The amplifier has

maximum gain when input 2 is 1.5V. When input 2 is -2V, the gain is reduced by 60 dB. Thus, at 100 MHz, a full 60 dB of automatic-gain-control range is available.

The amplifier has a third input for use in series feedback. The output feeds back to pin 3 via a single resistor, which controls the overall power gain of the amplifier. The second and third stage of the amplifier are bipolar, providing high power output. At 10 MHz, the output is capable of delivering 12 dBm into 50Ω with 1 dB of signal compression.

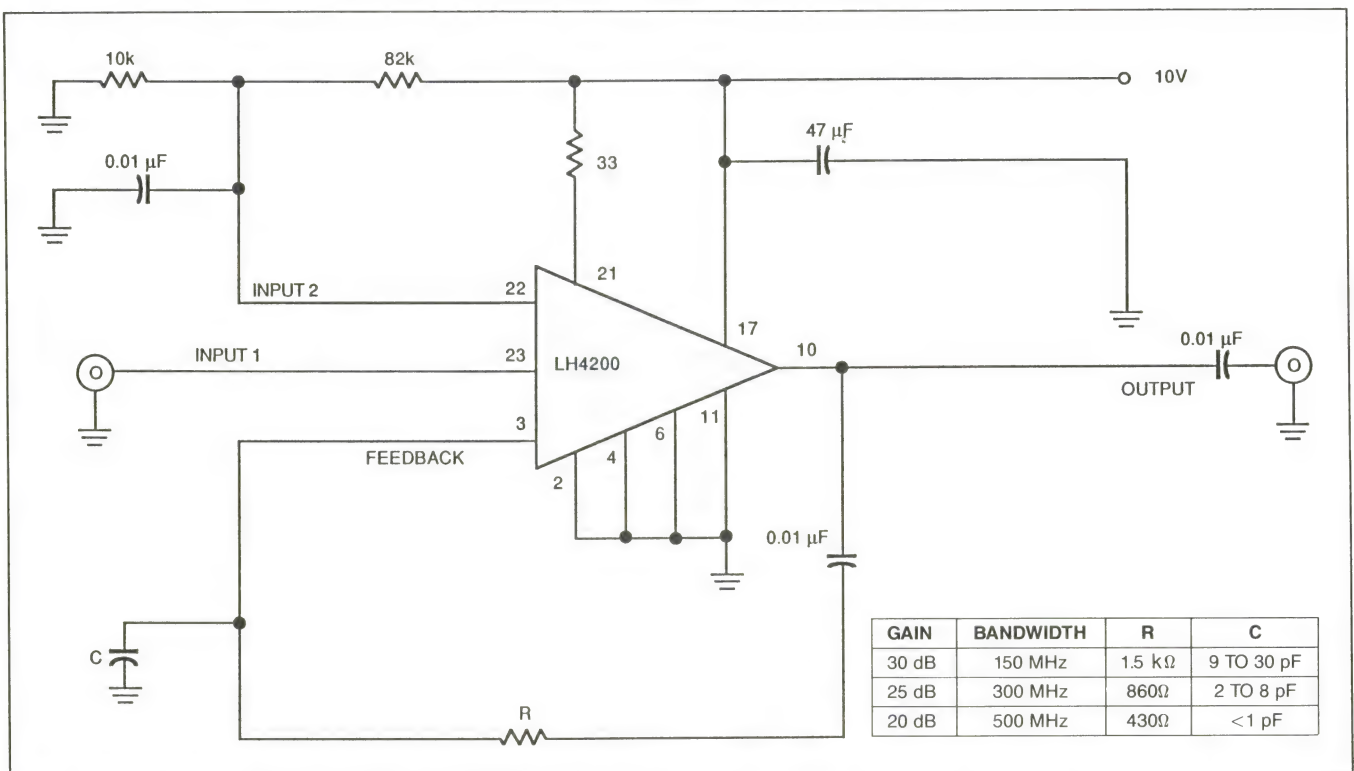
The ac-coupled amplifier has a

gain of 37 dB at 100 MHz and 3 dB at 1 GHz. You can cascade two amplifiers to get more than 60 dB of gain at 100 MHz.

The LH4200 has a noise figure of 3 dB at 50Ω and is powered from a single 10V supply; it requires 70 mA max of current. The amplifier comes in a 24-pin ceramic package. The commercial part (LH4200CD) costs \$54; the military version (LH4200C) costs \$66 (100).—*David Shear*

*National Semiconductor Corp, 2900 Semiconductor Dr, Santa Clara, CA 95052. Phone (408) 721-5856.*

**Circle No 733**

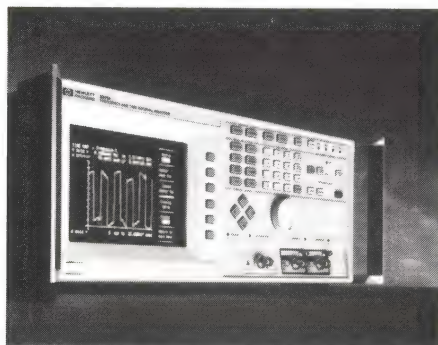


**When you use the LH4200 as a feedback amplifier,** you can control its gain with a single resistor in a series-feedback configuration. The accompanying table shows various gain/bandwidth options for the part. The only external decoupling required for this amplifier is the 47-μF electrolytic capacitor.

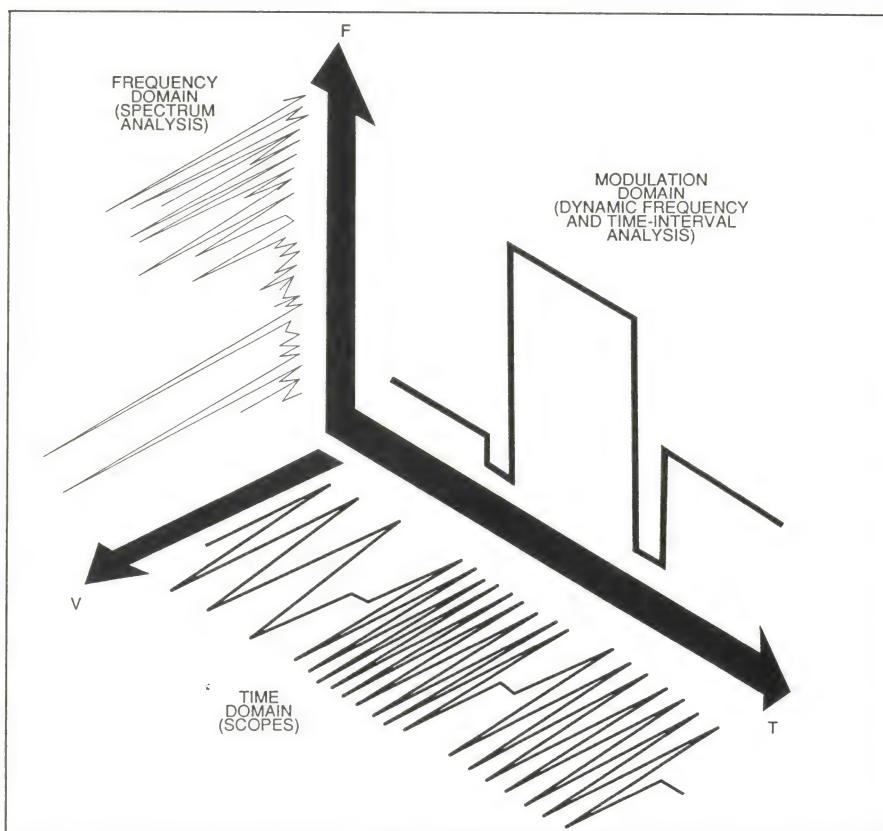
## Analyzer constantly monitors and displays 500-MHz frequency and interval variations

The 5371A is an unusual frequency and time-measuring instrument because it makes continuous measurements with no dead time between samples, even when the sampling interval is only 10 nsec (10M samples/sec). In addition, without external equipment, it can give you a picture of the way time-related quantities (frequency, for example) vary as a function of time.

Although many counters let you connect an external recorder to obtain plots of the trend of a measured quantity, only the 5371A offers continuous-measurement capability and an integral graphics display, the vendor claims. The 5371A can measure frequencies from 0.125 Hz to 500 MHz, pulse widths as short as 1 nsec and phase delays with 0.1° precision. The instrument's capabilities don't stop there, however. Built into its firmware are routines which, among other things, compute and display histograms of measurements and calculate statistical measures, such as standard deviation and variance.



Besides having a set of keys adjacent to firmware-generated legends on the screen, the 5371A's front panel also provides cursor arrows and both keypad and rotary controls for data entry.



**Fig 1—**The “modulation domain” is the term Hewlett-Packard coined to describe the measurement area where its 5371A excels, and to contrast the types of measurements it makes to those made by scopes and spectrum analyzers.

The instrument's ability to take near-instantaneous measurements, to perform them without interruption, and to reduce them to a readily understandable form should greatly simplify work on equipment such as frequency-agile and digital communication systems, radar and electronic-warfare systems, and electro-mechanical storage peripherals.

If you're trying to learn the full range of values assumed by a rapidly changing measured quantity, you can find it frustrating, and possibly downright misleading, to use an instrument (such as a counter) that

may miss significant data because it spends only a small fraction of the time actually taking measurements. In such applications, the 5371A, with its continuous-measurement capability, should prove particularly valuable. In addition, the 5371A can present the data in a form you can readily assimilate. For example, it can display a plot of frequency or time interval vs time, or a probability-density curve of the percentages of a sequence of measurements that fall into several user-defined value ranges.

You can understand the 5371A's

## UPDATE

significance by comparing it with oscilloscopes and spectrum analyzers. Think of three orthogonal axes representing voltage, frequency, and time (Fig 1). The scope displays voltage vs time (the time domain); the spectrum analyzer displays voltage vs frequency (the frequency domain); and the 5371A displays frequency vs time. The vendor calls this third measurement mode the "modulation domain." With tongue only slightly in cheek, the company's representatives suggest that "it's about time" you were able to make measurements in the modulation domain.

Because the 5371A's forte is measuring *variations* in time-related quantities, you have to be able to predict how much variability the instrument itself introduces into its measurements. With a 100-nsec measurement time (only  $10\times$  the period of the measured signal), curves on the data sheet show an uncertainty of  $\sim 100$  kHz when you measure a 100-MHz input; when you increase the measurement time to 1 sec, the uncertainty drops to  $\sim 10^{-3}$  Hz—10 parts per *trillion* of the measured quantity.

In the preceding examples, the frequency display changes in 20-kHz increments at the 10-nsec sample time and in  $2\times 10^{-2}$ -Hz increments when the sample time is 1 sec. One year after calibration, crystal aging adds another 20 Hz of uncertainty to a 100-MHz measurement. The HP 5371A costs \$21,500.

—Dan Strassberg

Hewlett-Packard Co, 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local sales office.

Circle No 732

## Programmable Anti-Alias Filters for Critical A/D Prefiltering

**848P8E Series are Elliptic lowpass filters providing extremely sharp roll-off for A/D prefiltering.**

### Features:

- 8 pole, 6 zero elliptic lowpass filters
- Digitally programmable corner frequency
- Shape factor of 1.77 at 80db
- 8 bit (256:1) tuning ratio
- Internally latched control lines to store frequency selection data
- Ideal for single or multi-channel applications
- Plug in, ready to use, fully finished filter modules
- Five frequency ranges to 51.2kHz

### Other Filter Products Available:

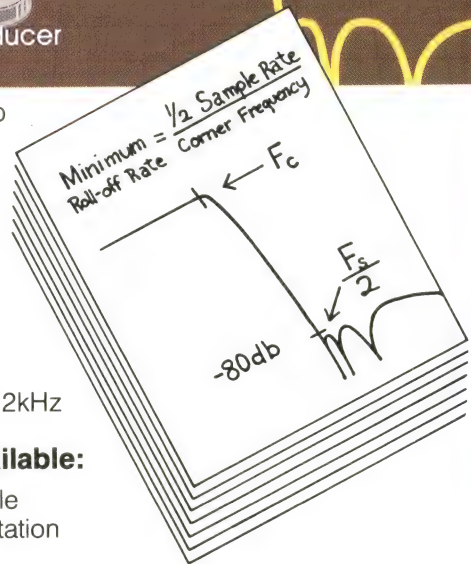
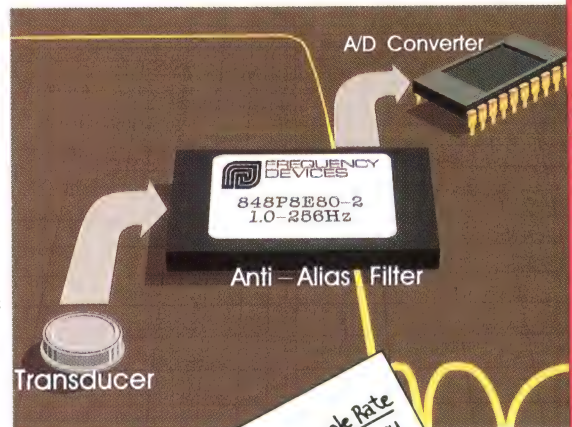
- Linear phase • Programmable
- Fixed frequency • Instrumentation
- Custom designs

For more information about how Frequency Devices can meet your most critical filtering requirements, call our applications engineers at (617) 374-0761.



**FREQUENCY DEVICES**

25 Locust Street  
Haverhill, MA 01830  
(617) 374-0761



CIRCLE NO 22

## DID YOU KNOW?

Half of all EDN's  
articles are staff-written.

**EDN**

# EDN NEWS

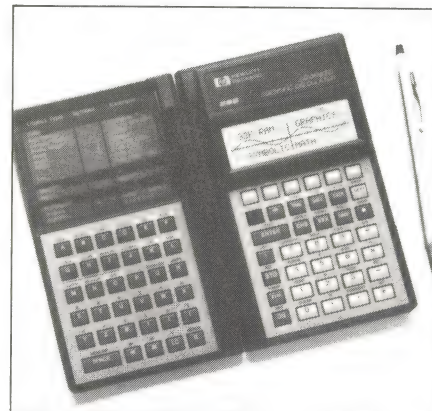
## PRODUCT UPDATE

### Two calculators suit manager and engineer

For the first time, the engineering manager can have a scientific calculator that also provides the financial functions usually found only on business calculators. The HP-27S (\$110) can perform "time value of money" operations (such as amortization) and forecasting operations, as well as the usual, basic scientific functions.

Meanwhile, the vendor has also upgraded the performance and user interface of its revolutionary HP-28C scientific calculator. The upgrade, designated HP-28S (\$235), has 32k bytes of user RAM (its predecessor had less than 2k bytes). Further, the HP-28S augments the HP-28C's unusual soft-key, menu-driven interface by allowing you to set up menus for your own functions.

Externally, the HP-28S differs only in graphics details from the HP-28C. Internally, the HP-28S has just two custom chips; the HP-28C had five.

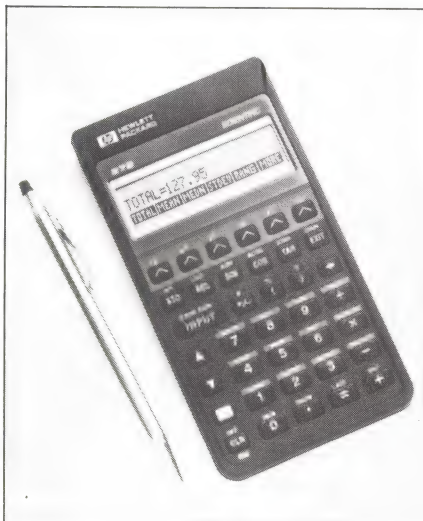


*With increased memory and an augmented user interface, the HP-28S scientific calculator supercedes the HP-28C.*

Both the HP-27S and the HP-28S have an infrared light-beam printer interface for the HP 82240A printer (\$135). Interestingly, for the purpose of reducing costs, the vendor did not make the printer interfaces bidirectional. The calculators depend on careful timing, rather than a Busy signal from the printer, to avoid overrunning the printer's buffer. Thus, neither calculator has any facility for external storage or retrieval of programs or data; you must key in every program step or datum manually.—**Charles H Small**

*Hewlett-Packard Co, Inquiries Manager, 1000 NE Circle Blvd, Corvallis, OR 97330. Phone (800) 752-0900 for nearest dealer.*

**Circle No 731**



*Offering both scientific and financial functions, the HP-27S calculator aids the engineering manager who must do engineering design as well as figure out budgets.*



## HOT NEWS OF PRODUCTS, TECHNOLOGY, AND CAREERS

# EDN NEWS

# IS SCOPE SETUP A SOURCE OF DELAY?

The Tek 2465A with AUTO SETUP is the time-saving solution. See up to four waveforms on-screen at the touch of a button. Your display is triggered and scaled automatically, without having to adjust a single knob. Add other standard features such as 350 MHz probe-tip bandwidth, 2 mV/div sensitivity and auto trigger level—all in a scope made for solving tough problems in analog design. It makes troubleshooting trouble-free!



## CUT IT OUT!

- ☐ Please send me your free videotape introduction, "The 2445A/2465A Family: From Performance to Productivity."
- ☐ Please send me your free 22-page brochure.
- ☐ Please have a Tek representative get in touch with me as soon as possible to arrange a demonstration.

In a hurry? Call Tek direct  
**1-800-426-2200**

D887-6-38AX EDN

**Yes! I want a closer look at the Tek 2445A/2465A Family.**

Name

Title

Company

Address

City

State

Zip

( )

Phone

Ext

**Tektronix**  
COMMITTED TO EXCELLENCE

# SCOPES CUT OUT FOR YOUR KIND OF WORK.

**Accurate measurements, accurately interpreted.** The 350 MHz 2465A builds on proven, industry-standard high performance. You can easily measure pulse parameters and frequency with on-screen cursors. Full bandwidth is maintained at 2 mV/div sensitivity to monitor low-amplitude signals such as noise and ripple with full fidelity.

You can make timing measurements with 20-ps resolution at sweep speeds to 500 ps/div. And trigger on 500 MHz signals from any one of four channels or on four asynchronous channels. Dual, delaying time bases mean precise measurements on complex waveform details.

**Measurement options, extended capabilities.** For specialized performance requirements, five combinable enhancements are available—a GPIB interface, digital multimeter, counter/timer functions with enhanced triggering, 17-bit word recognition and video measurement capabilities.

Three multiple-option packages, the 2465A Special Editions, are con-

Key Features	2465A DV	2465A DM	2465A CT	2465A	2445A
Probe Tip Bandwidth	350 MHz	350 MHz	350 MHz	350 MHz	150 MHz
No. of Channels	4	4	4	4	4
Horizontal Accuracy	2% (.001%*)	2% (.001%*)	2% (.001%*)	2% (.001%*)	2% (.001%*)
Max. Sweep Speed	500 psec	500 psec	500 psec	500 psec	1 nsec
Vertical Sensitivity	2 mV/div	2 mV/div	2 mV/div	2 mV/div	2 mV/div
Trigger Frequency	500 MHz	500 MHz	500 MHz	500 MHz	250 MHz
GPIB	Standard	Standard	Standard	Optional	Optional
Counter/Timer/Trigger/Word Recognizer	Standard	Standard	Standard	Optional	Optional
Digital Multimeter	Standard	Standard	Not Available	Optional	Optional
Video Trigger	Standard	Not Available	Not Available	Optional	Optional
Probes	4	4	4	2	2
Warranty	3 years on parts and labor, including CRT				

\*with Counter/Timer/Trigger

figured for specific application areas at a significant savings over the separately ordered options.

All models come with Tek's comprehensive three-year warranty on labor and parts, including the CRT.

**Get the full story!** Return the reply card, or call your Tek Sales Engineer for a hands-on demonstration. To place an order or request product literature, call Tek direct: **1-800-426-2200.**

## BUSINESS REPLY MAIL

FIRST CLASS PERMIT NO. 1 BEAVERTON, OR

POSTAGE WILL BE PAID BY ADDRESSEE

**Tektronix, Inc.**

Del. Station 02-050

P.O. Box 500

Beaverton, OR 97077

NO POSTAGE  
NECESSARY  
IF MAILED  
IN THE  
UNITED STATES

# READERS' CHOICE

Of all the new products covered in EDN's **October 15, 1987**, issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, find out what makes them special: Just circle the appropriate numbers on the Information Retrieval Service card, or refer to the indicated pages in our **October 15, 1987**, issue.



## ▲ PEN-GRIP DMM

The DM71 handheld, pen-type digital multimeter (DMM) features a 3½-digit LCD. The autoranging meter has 0.7% accuracy max and possesses a data-hold function (pg 254).

**Beckman Industrial Corp.**

**Circle No 605**

## CPU BOARDS

The 68020-based CPU-22/23 board facilitates message passing on the VME Bus and provides either 256k bytes or 1M byte of dual-port RAM (pg 83).

**Force Computers Inc.**

**Circle No 601**

**Force Computers GmbH**

**Circle No 602**

## PASCAL DEBUGGER

T-Debugplus version 2.0 is a symbolic run-time debugger for Turbo Pascal. It debugs programs that use CGA, EGA, or Hercules graphics modes (pg 245).

**TurboPower Software.**

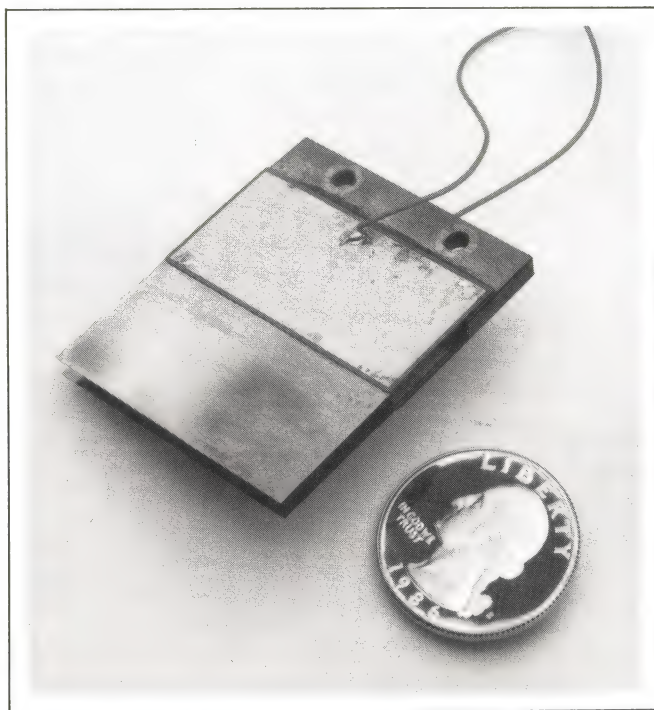
**Circle No 606**

## CHIP SET

The 5-member FE3500 chip set provides the core logic and the memory and I/O control necessary to implement a 16-bit, 80286-based, IBM PC/AT-type personal computer (pg 233).

**Faraday Electronics Inc.**

**Circle No 604**



## ▲ PIEZOELECTRIC FAN

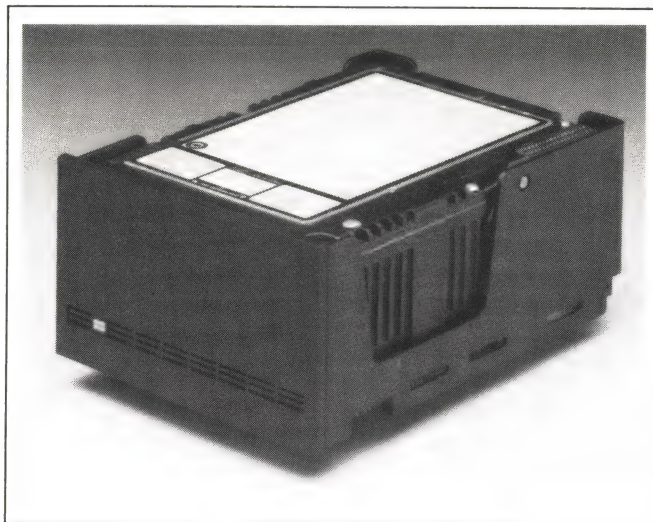
The LP24HT, a dc-operated miniature piezoelectric fan, produces a planar air stream that emanates from the front tips of its resonating blades (pg 216).

**Piezo Electric Products Inc.**

**Circle No 603**

# READERS' CHOICE

Of all the new products covered in EDN's **October 29, 1987**, issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, find out what makes them special: Just circle the appropriate numbers on the Information Retrieval Service card, or refer to the indicated pages in our **October 29, 1987**, issue.



## ◀ DISK DRIVES

The half-height 1600 family and the full-height 1500 family of 5¼-in. Winchester disk drives offer storage capacities of 180M and 765M bytes, respectively (pg 138).

**Micropolis Corp.**

Circle No 607

## VIDEO GENERATOR

The Montest-AD8 video generator uses an 8-MHz dot clock to generate four test patterns—full raster, color bars, crosshatch, and windows—at any of eight user-selectable scan frequencies from 15.75 to 31.5 kHz (pg 302).

**Network Technologies Inc.**

Circle No 611

## FORMAT CONVERTER

The Interchange package transforms data from the 5¼- to the 3½-in. disk format and lets you transfer data from IBM PCs to PS/2 machines (pg 318).

**SMT Inc.**

Circle No 612

## PLL SYNTHESIZER

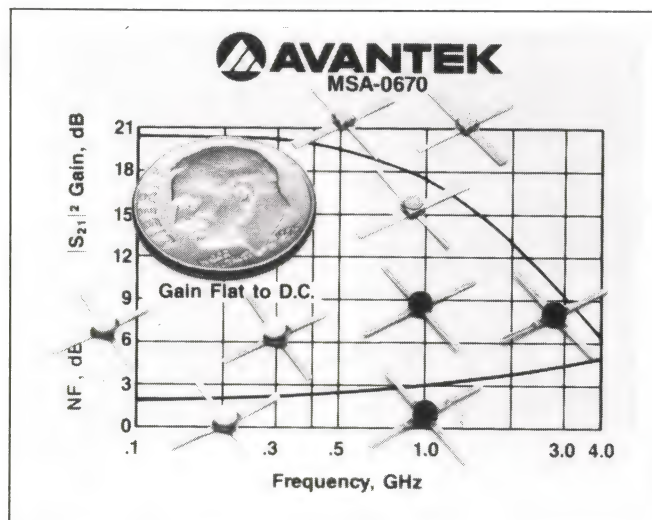
The TBB200 CMOS PLL frequency synthesizer operates in single- or dual-modulus modes and is intended for use in radio communications equipment (pg 274).

**Siemens Components Inc.**

Circle No 608

**Siemens AG**

Circle No 609



## ▲ AMPLIFIERS

These general-purpose monolithic microwave IC amplifiers are cascadable 50Ω gain blocks that can operate with power-supply voltages as low as 5V (pg 284).

**Avantek Inc.**

Circle No 610

# NOW YOU CAN DRIVE OUR SUBCOMPACTS.

Seagate's family of 3½" hard disc drives.



As computers grow smaller, the demand for high-quality drives grows larger. But if you're looking for 3½" drives for your small computer systems, you don't have a lot to choose from.

Except at Seagate.

We offer six 3½" drives with 21, 32 and 48 MB formatted capacities. You also have a choice of interfaces: SCSI or ST412 with RLL or MFM encoding. All with 28 msec access time.

Our 3½" drives use Seagate's field-proven, proprietary stepper motors to achieve fast access times normally found only with more expensive voice coil actuators.

Seagate's 3½" drives are not only fast — they're power savers, using as little as 8 watts. And for added data integrity, the drives feature autopark with a balanced positioner.

All of Seagate's 3½" drives are built with the precision and quality that have made us the world's leading independent manufacturer of 5¼" full-height and half-height hard disc drives.

Only Seagate has the worldwide, high-volume manufacturing efficiency to meet the growing demand for 3½" drives.

Once you evaluate Seagate's subcompacts, you'll be ready to go for a little drive. Call us today. 800-468-DISC.



 **Seagate**

The first name in disc drives.

# LEADTIME INDEX

Percentage of respondents

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
<b>TRANSFORMERS</b>								
Toroidal	0	16	63	16	5	0	9.3	8.7
Pot-Core	7	7	65	14	7	0	9.4	10.0
Laminate (power)	0	35	38	23	4	0	8.7	7.7
<b>CONNECTORS</b>								
Military panel	0	15	38	39	8	0	11.5	11.2
Flat/Cable	12	42	29	13	4	0	6.6	5.4
Multi-pin circular	0	14	50	36	0	0	10.0	8.2
PC (2-piece)	5	21	63	11	0	0	7.3	5.8
RF/Coaxial	18	29	35	18	0	0	6.4	5.1
Socket	14	41	38	7	0	0	5.3	3.6
Terminal blocks	12	40	40	8	0	0	5.6	4.5
Edge card	6	33	56	5	0	0	6.3	6.4
D-Subminiature	13	29	50	8	0	0	6.2	4.5
Rack & panel	6	41	35	18	0	0	6.8	7.4
Power	6	41	29	24	0	0	7.2	7.4
<b>PRINTED CIRCUIT BOARDS</b>								
Single-sided	5	57	33	5	0	0	5.1	5.9
Double-sided	0	34	57	9	0	0	6.9	6.9
Multi-layer	0	9	86	5	0	0	7.9	7.7
Prototype	7	79	14	0	0	0	3.5	4.2
<b>RESISTORS</b>								
Carbon film	40	30	27	3	0	0	3.6	3.3
Carbon composition	38	31	28	3	0	0	3.1	5.0
Metal film	23	40	34	3	0	0	4.4	4.4
Metal oxide	19	44	31	6	0	0	4.8	4.9
Wirewound	6	26	55	13	0	0	7.2	5.8
Potentiometers	6	41	41	12	0	0	6.4	5.0
Networks	14	45	41	0	0	0	4.7	5.7
<b>FUSES</b>								
	32	42	21	5	0	0	3.8	3.8
<b>SWITCHES</b>								
Pushbutton	11	44	30	15	0	0	6.0	4.8
Rotary	0	48	35	13	4	0	7.3	5.3
Rocker	12	44	32	12	0	0	5.7	5.2
Thumbwheel	9	29	33	24	5	0	8.4	6.2
Snap action	14	36	43	7	0	0	5.6	5.0
Momentary	4	55	32	9	0	0	5.6	6.3
Dual in-line	0	43	50	7	0	0	6.4	6.2
<b>WIRE AND CABLE</b>								
Coaxial	36	36	28	0	0	0	3.3	3.7
Flat ribbon	21	46	33	0	0	0	4.0	3.7
Multiconductor	27	32	36	5	0	0	4.6	4.5
Hookup	35	42	23	0	0	0	3.1	3.5
Wire wrap	28	18	54	0	0	0	4.8	4.4
Power cords	26	44	19	11	0	0	4.5	4.9
<b>POWER SUPPLIES</b>								
Switcher	5	15	50	20	10	0	10.1	8.3
Linear	6	19	44	25	6	0	9.5	7.8
<b>CIRCUIT BREAKERS</b>								
	0	24	57	19	0	0	8.2	7.1
<b>HEAT SINKS</b>								
	10	35	45	10	0	0	6.2	5.0
<b>RELAYS</b>								
General purpose	8	33	42	17	0	0	6.9	5.6
PC board	0	33	38	29	0	0	8.5	6.9

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
<b>RELAYS</b>								
Dry reed	0	36	27	37	0	0	8.9	7.0
Mercury	0	30	40	30	0	0	8.8	8.8
Solid state	6	35	35	24	0	0	7.5	9.0
<b>DISCRETE SEMICONDUCTORS</b>								
Diode	17	31	25	22	5	0	7.8	5.1
Zener	12	29	24	29	6	0	8.8	5.5
Thyristor	10	16	32	42	0	0	9.5	7.9
Small signal transistor	4	38	29	21	8	0	8.8	5.7
MOSFET	0	50	23	23	4	0	8.0	9.0
Power, bipolar	0	40	40	20	0	0	7.5	8.0
<b>INTEGRATED CIRCUITS, DIGITAL</b>								
Advanced CMOS	5	24	33	38	0	0	9.3	7.3
CMOS	4	28	36	32	0	0	8.7	6.5
TTL	19	39	27	15	0	0	5.7	5.9
LS	18	39	25	18	0	0	5.9	5.2
<b>INTEGRATED CIRCUITS, LINEAR</b>								
Communication/Circuit	0	38	25	37	0	0	8.9	8.5
OP amplifier	11	26	37	26	0	0	7.8	7.1
Voltage regulator	7	45	27	21	0	0	6.8	5.8
<b>MEMORY CIRCUITS</b>								
RAM 16k	19	33	14	34	0	0	7.3	4.1
RAM 64k	13	30	26	31	0	0	7.7	6.5
RAM 256k	22	11	22	39	6	0	10.0	6.7
RAM 1M-bit	8	17	25	42	8	0	11.1	11.8
ROM/PROM	0	47	13	40	0	0	8.7	7.7
EPROM 64k	8	33	21	38	0	0	8.5	6.5
EPROM 256k	5	32	21	37	5	0	9.7	7.5
EPROM 1M-bit	0	14	22	50	14	0	13.5	10.5
EEPROM 16k	0	36	21	43	0	0	9.4	8.5
EEPROM 64k	7	27	20	46	0	0	9.6	8.5
<b>DISPLAYS</b>								
Panel meters	8	38	31	23	0	0	7.2	6.4
Fluorescent	0	10	30	50	10	0	13.0	9.4
Incandescent	12	38	0	50	0	0	8.9	6.9
LED	8	46	23	23	0	0	6.8	5.4
Liquid crystal	0	30	35	29	6	0	9.8	8.6
<b>MICROPROCESSOR ICs</b>								
8-bit	8	40	20	32	0	0	7.8	6.8
16-bit	10	33	9	48	0	0	9.1	7.0
32-bit	6	35	18	41	0	0	8.9	9.8
<b>FUNCTION PACKAGES</b>								
Amplifier	0	22	33	45	0	0	10.2	8.0
Converter, analog to digital	7	13	40	40	0	0	9.8	7.9
Converter, digital to analog	0	8	50	42	0	0	10.7	8.0
<b>LINE FILTERS</b>								
	7	26	47	20	0	0	7.6	7.3
<b>CAPACITORS</b>								
Ceramic monolithic	10	38	38	14	0	0	6.3	5.7
Ceramic disc	13	33	37	17	0	0	6.5	5.7
Film	15	27	35	19	4	0	7.5	5.9
Aluminum electrolytic	12	34	30	24	0	0	7.2	7.1
Tantalum	8	32	41	19	0	0	7.1	6.9
<b>INDUCTORS</b>								
	5	27	50	18	0	0	7.6	6.3

Source: Electronics Purchasing magazine's survey of buyers

When you're designing ICs,

# The Last Thing You Need is Silicon.

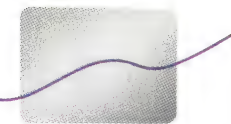
Before you commit your IC design to silicon, you can design your circuit, simulate it, test it, analyze it, and *even estimate manufacturing yields* with the IC Design Tool Kit

from Analog Design Tools.

Offered as an addition to the popular Analog Workbench™ and PC Workbench™ software, you can use the kit with your own models and simulators, remote computers, and a variety of popular CAE/CAD

software and workstations. And the model library, tailored specifically for IC design, includes active and passive components that contain modifiable process-related parameters that are tracked through all of the components on the chip.

If you design ICs, the *first* thing you need is an advanced CAE tool. See the best in action: call 1-800-ANALOG-4 and ask for a FREE Demo Disk or Video.



ANALOG  
DESIGN  
TOOLS

1080 East Arques Avenue  
Sunnyvale, CA 94086  
408-737-7300 or 1-800-ANALOG-4

© 1987 Analog Design Tools, Inc.  
Analog Workbench and PC Workbench are  
trademarks of Analog Design Tools.



## Special Report



**Real-time operating systems** help speed software development by linking computer resources to your code modules. (Photo courtesy Ready Systems)



# Real-time operating systems

---

*A real-time operating system can enable you to design and write a large real-time software system as a collection of simple, potentially reusable routines. It can also help you avoid some difficult bugs common to real-time programming. But using a formal real-time OS system means learning a completely new programming style.*

---

Charles H Small, *Associate Editor*

Two groups of software engineers face the need to adopt real-time operating systems: embedded-system, assembly-language programmers who are now confronting applications so large and complex that the projects demand formal programming methods (Ref 1), and high-level-language programmers who must use Ada. Although high-level-language programmers are comfortable with the complex tools, elaborate operating systems, and formal design methodologies needed for developing robust, maintainable software systems, and high-level-language and assembly-language programmers are familiar with the intricacies of real-time processing, both groups are entering unfamiliar territory when they begin to use real-time operating systems.

Using a real-time operating system to encase your application is like wearing armor into battle. The ar-

mored knight was better protected than an unarmored warrior. But the extra weight he was carrying also made him slower and less agile. A real-time operating system, especially when coupled with other, formal software-engineering methods, provides protection against the kinds of software disasters and blunders that unstructured development sometimes produces. Unfortunately, writing an *ad hoc* real-time system also extends the opportunity to write impenetrable "spaghetti" code (unstructured code) into another dimension—that of time.

But a real-time operating system's protection comes at a price—extra CPU overhead. Also, submitting to the discipline of formal software-design methods means you will have to restrict the scope of your ingenuity and creativity to within the confines of the tool set the real-time operating system provides.

## **Real-time OS isn't just a check-off item**

Many software engineers decide to write their own real-time executives. Who can blame them? A real-time executive is one of the most exciting projects a software engineer can undertake. And not every application needs a real-time operating system. Just because your application performs I/O operations does not mean you need an operating system. Further, if the state diagram for your application looks like a string of pearls, your application is batch oriented and will not benefit from concurrent processing. Further, some applications require such high throughput that they can't tolerate the overhead of any operating system, whether it's a real-time one or not.

Despite the attraction of writing your own real-time



Industry observers report a disturbing trend among prospective first-time users of real-time operating systems to treat the real-time operating system as a check-off item (see **box**, “Considerations in operating-system selection”). No two available real-time operating systems are equivalent. Choosing an operating system demands close and careful examination.

116

Two classes of real-time software exist: full operating systems (which include kernels) and stripped-down kernels themselves. Full operating systems are generally disk-based and are loaded into the host from disk every time you start up the host. Onboard ROMs, on the other hand, usually store kernels. The kernels are generally small in size, ranging from 2k bytes to as much as 100k bytes. For example, US Software's USX occupies fewer than 3k bytes.

These distinctions are not clear-cut, however. Many full-blown operating systems such as Alcyon's Regulus, Microware's OS/9, and Intel's iRMX offer a subset of the operating system as ROMable kernels. And kernel makers such as Ready Systems and Software Components Group have file and debugger options that you can add to their basic kernels. Most do what JMI Software Consultants Inc has done for its C Executive—they offer run-time libraries you can use to call the real-time operating kernel's primitives from your high-level programs. Further, JMI has rewritten 300 common Unix run-time libraries so that they are re-entrant and ROMable and so they can be used in a real-time system. In other words, the kernel manufacturers are moving toward full-blown operating systems while the operating system makers are moving toward kernels.

Generic operating systems are, by definition, more portable than specially targeted systems. Assembly-language operating systems, on the other hand, can be faster and more compact than ones written in high-level languages. And an operating system targeted for a

## Considerations in OS selection

You'll probably already have selected a  $\mu$ P and system bus for your real-time system before you begin to look for a real-time operating system or kernel. When choosing a system, consider—at minimum—the following characteristics:

- Response time (interrupt latency)
- Kernel or full operating system
- Coprocessor support
- Multiprocessor support
- Other hardware support—clocks, timers, interface chips, buses
- Other  $\mu$ Ps supported
- Software drivers—terminal, I/O boards, disk, tape, networks, graphics
- Host development aids
- Target-system, ROM-resident monitor
- Debugger
- Performance analyzer (program profiler)
- License fees.

specific  $\mu$ P can more easily take advantage of a given  $\mu$ P's special features.

Some of the memory-protection hardware of advanced  $\mu$ Ps suits multitasking systems. This hardware can keep one task from corrupting the program or data of another task. Some advanced  $\mu$ Ps have special instructions for task switching, semaphore signaling, and debugging. But some features of advanced  $\mu$ Ps impede real-time processing.

For example, a numeric coprocessor can increase the number of registers and the amount of data that a real-time operating system must save and restore when doing a context switch. And context switching, like subroutine jumping, destroys the effectiveness of instruction-prefetch queues and cache memories. Further, no advanced  $\mu$ Ps come with features that handle common real-time operating-system overhead such as prioritized-list management.

### Computer boards come with real-time OSs

As evidence of electronics engineers' growing interest in real-time operating systems, computer-board manufacturers are beginning to offer specially targeted real-time-operating-system ROMs along with their CPU boards. Along with its 68020-based VME boards, for example, Force Computers now offers a

customized, ROM-resident version of Eyring Research Institute's PDOS operating system at no extra charge. The 16-bit  $\mu$ P versions will appear later. Force's subset of PDOS functions, dubbed the VMEPROM, includes a file manager and basic I/O modules, as well as RAM-disk support, a screen editor, disk utilities, and a debugger.

Dyad Technology Corp has a board with a version of Ready System's VRTX that's specially designed for the IBM PC. You can even get real-time operating systems for the smallest of computing engines: single-chip  $\mu$ Ps. Avocet Systems Inc, Intelligent Machinery Co, and Micro Computer Control have high-level language compilers and real-time operating-system kernels for  $\mu$ Ps such as the 8051 family. In particular, the Intelligent Machinery Co's imx/51 manual comes with numerous functional, clearly written examples that serve as a tutorial on real-time programming for the 8051 family.

### Introduction to new tools and design methods

But simply deciding to adopt an operating system is only the beginning of the transformation you must undergo when switching from writing ad hoc, sequential code and operating systems to more formal, real-time coding. Real-time operating systems are but one weapon in a software engineer's panoply. The real-time operating system is an armature upon which you hang your application. No matter how robust the operating system's mechanisms may be, they can't make up for a poor design. Long before you actually begin to write routines that invoke the operating system's resources, you should perform a thoroughly documented, top-down design.

For example, to make effective use of an operating system's intertask-communication mechanisms, you should have a clearly thought-out data-handling protocol along with a complete data-flow diagram.

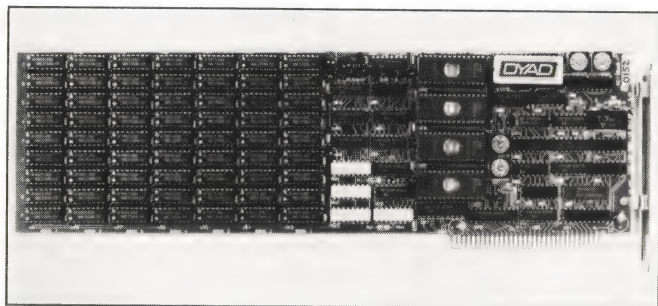
Real-time operating systems generally do not do much error checking and exception handling. Therefore, you must set up and enforce rules to ensure that your tasks pass properly formatted messages and parameters that are within specified ranges. You must also set up your own error-checking and error-recovery routines.

According to US Software, you should carefully chart all intertask communication before writing your programs. Such a chart will greatly reduce debugging and "thrash" time you might otherwise spend when checking out your system. The firm does not suggest that the communication chart can take the place of other design

---

*Any real-time, multitasking OS that performs pre-emptive scheduling must occasionally turn off either its scheduler or the  $\mu$ P's external interrupts.*

---



**With the aid of this plug-in, real-time operating-system board from Dyad Technology, you can get real-time performance from your IBM PC.**

documentation, but rather that it's an adjunct to that documentation.

The firm recommends that the communication chart should include (as source and destination points) tasks, common-code routines, and user-interrupt routines. You should annotate the arrows between these points to indicate the direction of data flow as well as the type of communication (event parameters, accept or release, clear or set, mailbox, message type, wake-up call, etc) and any other useful information.

At present, only Ready Systems can supply computer-aided tools for formal design methods that apply specifically to real-time systems. Without Ready Systems's Cardtools, you will have to do your formal, top-down design, and documentation manually. Cardtools can produce software documentation in the style of DoD-STD-2167 (which is required in Defense work).

Cardtools is an elaborate suite of programs whose functions span three phases of a formal software-engineering project: software-requirements specification, high-level design, and detailed design. After these three phases, you are still left with coding and testing, integration and debugging, installation and operation, and maintenance.

Cardtools begins with a graphics-oriented diagram and text editor with which you can decompose functional and data specifications to any number of levels. Like all the programs in the Cardtools package, the specification tool saves all the data you enter in a common Cardtools database. And, because it is more than a passive graphics editor, it does completeness and consistency checks as well.

Next, the package's rapid-prototyping facility lets you set up user screens. It automatically generates source code for the displays. (In computer-aided software-engineering (CASE) circles, rapid prototyping generally means dummifying up the user interface. The

resulting dummy prototype often passes for a demonstration program.)

Another tool then prompts you for complete specifications for logical and numeric data definitions. Hopefully, by declaring I/O parameters early in the design cycle, you will be able to catch such errors as misrepresentation of data, out-of-range excursions, and design overkill.

An Ada-related tool allows you to build libraries of related functions into Ada "packages." This tool helps you follow the Ada programming style and additionally gets you thinking early on about reusable routines.

By this point in the sequence of applying the tools, the Cardtools database has acquired much information about your design. It can now automatically produce a data-flow diagram (but you can draw your own, if you wish). Nearly all software-engineering gurus recommend a comprehensive data-flow diagram as an aid to rational, reliable use of an operating system's communications and task-synchronization primitives.

Cardtools even has a program that will help relieve the principal source of anxiety for real-time software engineers—especially those unaccustomed to real-time systems; it provides an early estimate of the most important spec for a real-time system—its speed. The package's real-time performance-verification tool performs critical-path analysis on your design's multitasking architecture. The tool uses the specifications you entered in the Cardtools database to evaluate your system's timing response.

Last, a program-design-language (PDL) editor and analyzer accepts and checks structured-English (psuedolanguage) versions of your program's routines. Ready Systems claims that using a PDL editor before beginning to code in your real high-level language increases work at the design stage by 5% but trims 15% off the overall design effort.

Software engineers who must work with Ada should remember that Ada is not just a compiler. The Ada specification covers all phases of a project from specification to debugging. At present, Ada users have enough to worry about just to find an efficient compiler. But eventually, Ada tools will have to expand their coverage to meet all DoD specs.

### **Guidelines for task splitting**

However you design your real-time system, manually or with CASE tools, the most important phase of the design is dividing the application into tasks. While no hard-and-fast rules apply to partitioning an application

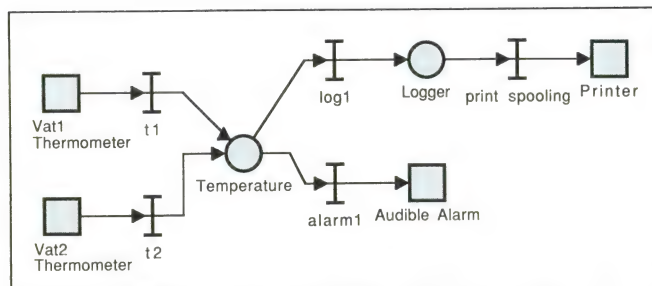
into tasks, some general guidelines apply. First, you should split the processing load into small tasks, each task having generally only one function. A task, therefore, is the smallest unit of execution that can compete on its own for system resources. A task inhabits a virtual, insulated environment that the real-time operating system provides. In this environment, the task can use—or, if necessary, can wait until it can use—any of the real-time operating system's resources without explicit concern for any other tasks in the system.

You should divide your tasks so as to minimize intertask communication. Too much intertask communication exacts a penalty in the form of too much operating-system overhead. Because intertask communication increases dependencies among tasks, intertask communication is at odds with the goal of partitioning software into autonomous tasks. If you find your application doing too much intertask communication, you may have partitioned your tasks poorly, or you may be trying to use a real-time operating system in an application it's not suited for.

Naturally, you must devote considerable thought to assigning priorities to tasks. Do not confuse priority with the amount of CPU time a task will consume. You could very well have a very-high-priority task that runs infrequently, and that, when it does run, runs for a short time before going back to sleep. Conversely, you could have a low-priority task that consumes the bulk of the CPU time but can tolerate interruptions at any time.

Similarly, don't confuse hardware-interrupt priority with software-task priority. You could have an input or output port with a high hardware priority—a high-speed data link, for example. But a simple hardware-interrupt handler could respond to the high-priority hardware interrupts and do no more than put the characters from the high-speed link into a buffer for later processing by a low-priority task. This situation is not uncommon because many I/O channels are "bursty" in nature; that is, they have short, intense bursts of communication interspersed with long periods of inactivity.

Generally, the system-clock interrupt has the highest priority for real-time operating systems that do time slicing. You may have to assign some other hardware interrupt a higher priority, but in so doing, you may disrupt your system's timing. Because the priority of tasks influences the performance of the overall system, be prepared to do some experimentation until you fine-tune your system's performance sufficiently.



*In this data-flow diagram of a real-time system, squares are external devices, I-beams are communications interfaces, and circles are tasks. The diagram was produced with a graphics editor, from Andyne Computing, that allows you to document the structure of a real-time system.*

In all cases, you must partition processing not only among tasks, but also between interrupt handlers and their respective tasks. The general rule is to make interrupt handlers as short as possible and to do as little processing as possible in the handler.

### Dangerous calls for interrupt handlers

Even though your interrupt handlers must be as short and fast as possible so as to minimize the time the  $\mu$ P turns off interrupts during an interrupt service, interrupt handlers still interact frequently with the operating system and your higher-level tasks in the system. For example, the interrupt handler might have to acquire a memory buffer from a memory pool. Not all of a kernel's function calls are safe for an interrupt handler to make.

Generally, an interrupt handler can make with impunity any call that creates a structure. Interrupt handlers can write and read data as safely as any other software entity can, providing they obey the protocols you've set up for your system.

Any kernel function call that sends the operating system a signal that could change the state of a task can be dangerous if the handler does not first lock the system scheduler. You should use caution when employing such calls in an interrupt-service routine simply because interrupt-service routines occur asynchronously by nature, and they could cause unexpected behavior in the tasks they affect.

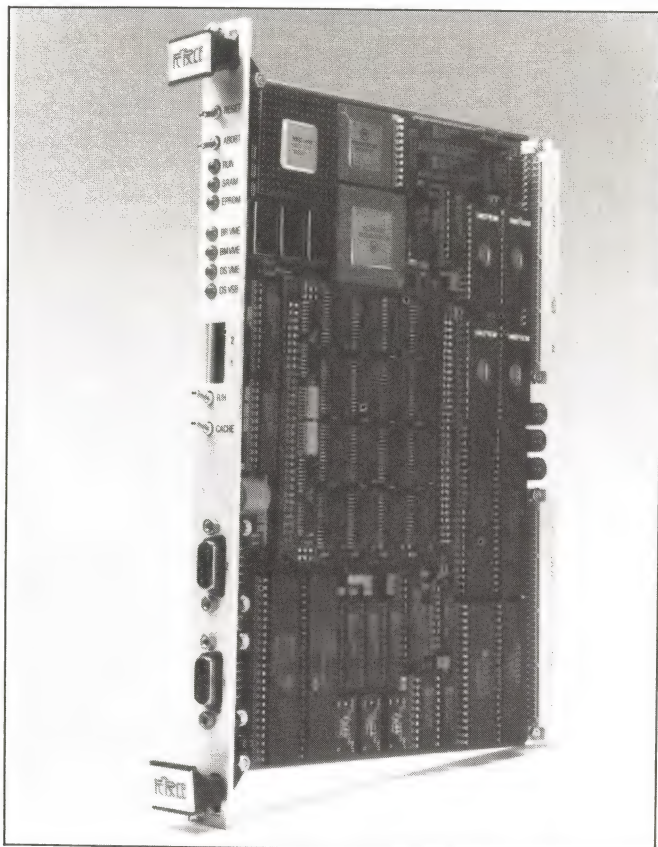
Even more dangerous for interrupt handlers to call are blocking commands that lock out high-level tasks from a memory area or a system resource. Further, you should not allow interrupt handlers to perform system calls that create or delete tasks.

After you've designed your real-time system, you will have to begin coding the individual modules and

---

*Critical regions in the operating system and in your task's code both affect the most important specification for real-time systems: interrupt latency.*

---



*Because of demands by engineers, board-level-computer makers such as Force Computers are supplying ROM-resident real-time operating systems for their computer boards.*

tasks. Encoding a real-time software design is challenging. For example, you must often write re-entrant code. Re-entrant code proves useful in real-time systems for two reasons: First, it saves space, because many tasks can use the same re-entrant code simultaneously. The fastest real-time systems keep all code in memory; a practice that puts a premium on a compact coding style. Second, re-entrant code exactly suits multitasking because, by definition, you can interrupt a process using re-entrant code at any point in the code segment, and later restart the process with no adverse effects.

Some languages, such as Forth, produce inherently re-entrant code. Other languages require discipline on the part of the programmer and a special compiler that produces ROMable code. Making a routine re-entrant simply means that the code can't modify itself; for example, all variables must reside in an area private to the task using the code, not in the code itself. The penalty for using re-entrant code can be increased overhead and more CPU cycles, because read and write

operations are indirect rather than immediate.

In addition, for re-entrant coding, you may wish to adopt object-oriented programming (**Ref 3**). Proponents of object-oriented programming claim that unless you use object-oriented programming, your real-time system will become unmanageable and incomprehensible if you have more than seven to 10 tasks.

Of the languages commonly used by EDN readers, only Forth offers straightforward programming facilities for building classes of objects. If you choose to adopt the object-oriented programming style and use other languages, you'll need to exhibit some programming discipline (**Ref 4**).

In addition to its real-time kernel, Intel's iRMX offers an elaborate set of function calls for manipulating objects. Thus, if you have the discipline to write object-oriented programs, you can put your objects under the control and protection of iRMX.

#### Using operating-system primitives

The biggest difference between sequential programming and writing programs that will run under a real-time operating system is, of course, actually using the real-time operating system's primitives. Each real-time operating system is a universe unto itself. No two operating systems mean quite the same thing when they call their primitives "semaphores" or "mailboxes," for instance. Each real-time operating system provides a suite of primitives having subtly, but significantly, different properties.

Although it's not difficult to find superficial descriptions of real-time-operating-system primitives, explanations of how they actually work are rare. It's worthwhile considering the subject in depth, however. If you understand how real-time-operating-system function calls work and how to use them, you'll find that they're trickier than they seem at first blush. Understanding how they work will also help you decide, first, whether you want a real-time operating system at all, and then, whether you'll write your own or buy a ready-made one. The following discussion will attempt to give you some idea of how real-time operating system function calls work and how to use them.

After splitting your application into tasks, you'll need to set up intertask communication channels, ensure that the tasks are properly synchronized, and use protection mechanisms so that they don't interfere with each other.

Any real-time, multitasking operating system that performs prioritized, pre-emptive scheduling must oc-

asionally turn off either its scheduler or the processor's external interrupts—or both—to allow a task to execute what are termed "critical" code regions.

A critical region is any program sequence, in one of the system's tasks or within the operating system itself, which cannot tolerate being interrupted. Take, for example, the prioritized lists that operating systems must constantly update. If the operating system is in the process of ordering a list of prioritized tasks, it must not be interrupted by a task that wants to change its priority or by a task that wants to join the queue until it's finished ordering the tasks at hand.

Similarly, a task could be updating or accessing a shared area of memory. The task must be able to work with the shared memory without the risk that some other, higher-priority, task will interrupt and change the common memory before the lower-priority task is finished. Protecting these critical code regions obviously affects the system's ability to process interrupts in a timely fashion, because lower-priority tasks can lock out higher-priority ones.

### Lengthening interrupt latency

Critical regions in the operating system and in your task's code both affect the most important specification for real-time systems: interrupt latency. If the operating system, or your tasks, have turned off interrupts or disabled task scheduling, a delay will occur before an interrupt is serviced or processing begins. Obviously, a maker of real-time operating systems can't supply a spec for how your critical regions will affect interrupt latency.

But the complexities of the inner workings of real-time operating systems make giving clear-cut, useful specs for interrupt latency difficult for makers of real-time operating systems to supply as well. Even if one particular maker *can* supply a useful spec for its system, the specs depend heavily on the hardware used (the  $\mu$ P, memory, memory manager, coprocessor, etc) and the software test setup (the number of tasks in the test system and the synchronizing scheme selected, for example). This lack of uniformity of test conditions makes comparing latency specs for competing real-time operating systems next to impossible.

The performance of some real-time operating systems depends on how many tasks the operating systems are handling and what state the tasks are in. Pre-emptive, prioritized real-time operating systems must manage many lists and queues. These operating systems must constantly update their lists and queues in

response to external interrupts and operating-system calls from tasks. Depending on just how a real-time operating-system designer writes his code, the real-time operating system's overhead can increase as the number of tasks increases simply because the real-time operating system has more items to keep track of.

Other task-dependent effects on an operating system's interrupt latency can arise from the management of queues attached to common data structures and intertask-communications mechanisms. As the number of tasks waiting grows, the operating system's overhead for managing these resources can grow. These and other sources of variable interrupt latency can bedevil a user of real-time operating systems because most real-time systems must meet a minimum interrupt-response specification.

One real-time operating system sidesteps many of these problems by simply having no scheduler and little need for critical-code lockouts. The operating system, Forth Inc's PolyForth, has an extremely simple mechanism for task switching that entails minimal overhead. Further, it relies on self-scheduling tasks rather than a pre-emptive scheduler to initiate task switching and thus avoids scheduler overhead simply by having no scheduler. PolyForth's schema is easy to understand and you could easily copy it if you wished to concoct your own real-time operating system.

PolyForth's task switching starts from a simple idle loop. Each task in the system has a Long Branch—or Long Jump—instruction at the head of its task area. The argument of the Long Branch instruction is the address of the head of the next task in the idle loop. When all the tasks are quiescent, and the idle loop is running, the system's  $\mu$ P simply jumps from task to task endlessly in round-robin fashion.

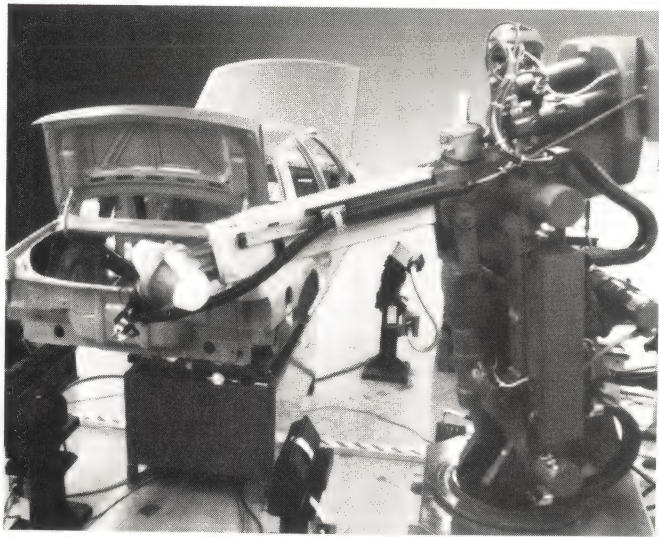
When the  $\mu$ P receives an external interrupt, it vectors to an interrupt handler. Unlike more complex systems that interpose the operating system between an interrupt handler and its associated task, each PolyForth handler knows which task it must work with. The handler performs any time-critical processing needed by the external interrupt and, just before executing a Return instruction, changes the argument of its associated task's Long-Branch instruction from the next task's address to the entry point of a routine that wakes tasks up.

Whenever the idle loop finally jumps to a task that an interrupt handler (or, perhaps another task) has marked for awakening, the idle loop detours to the wake-up routine. The wake-up routine knows which

---

*The complexities of real-time operating systems make it difficult for the OS vendors to give clear-cut, useful specs for interrupt latency.*

---



**Because robotic vision systems must respond to sensory inputs as they perform their tasks, they require real-time operating systems.** (Photo courtesy Software Components Group)

task needs to be awakened because the task's address is on the  $\mu$ P's return stack. The wake-up routine restores the task's registers and transfers control to the task's program so that the task can pick up where it left off in its program.

The task now has control of the  $\mu$ P, and only external interrupts can temporarily take control away from it; no other task can pre-empt the controlling task. No other high-level task can get control of the  $\mu$ P and begin running unless the currently running task voluntarily relinquishes control. In other words, PolyForth needs no scheduler because it is self-scheduling.

The Forth programmer has two ways of putting a task to sleep: The programmer can insert a Pause or a Wait command in the program's flow. If a task pauses, it puts itself to sleep and jumps to the next task in the idle loop. But it leaves its Long Branch instruction in the head of its task area, pointing to the wake-up routine. Thus, the next time the idle loop reaches the task, it will wake up. Alternatively, if the task executes a Wait, it puts itself to sleep and changes the argument of its Long-Branch instruction to the address of the next task in the idle loop. In this case, the idle loop will not activate the task; it will remain asleep until some external agent—an interrupt handler or another task—marks it for awakening.

Several characteristics of Forth facilitate this simple scheme; not all high-level languages could use this scheme as easily. Saving or restoring a Forth task—a context switch—takes little time because Forth uses

only three  $\mu$ P registers. A Forth task initiates a context switch by executing a Forth word. (Executing a Forth word is equivalent to calling a subroutine in other languages; in fact, executing subroutines is the fundamental, native way in which Forth programs execute.) By initiating task switches with Forth words, rather than at the arbitrary behest of an operating system, a Forth task naturally breaks its execution after completion of a routine rather than being interrupted in the middle of doing something. Breaking at the end of a function decreases the amount of data that the context-changing routine must save, because well-written Forth words generally tidy up system resources before exiting.

And because no task can pre-emptively interrupt another task, the programmer need only worry about interrupt handlers corrupting resources (a data structure, common memory area, or intertask communication or synchronization mechanism) while the task is working with them. Thus, PolyForth does not need many of the complex critical-code-lockout and protection schemes of pre-emptive operating systems.

The success of PolyForth's schema rests on your ability to fine-tune your overall system by peppering each task with judiciously placed Pauses and Waits so that no one task can hog the system. As it does in many other areas, Forth leaves it to you to custom-make constructs and functions that other operating systems and languages come with. For example, you'll have to write your own arrays, semaphores, mailboxes, and servers.

On the other hand, some unique hardware is available for Forth. Most languages are customized for certain hardware. Like Lisp, however, Forth has hardware customized for the language. You can get a Forth  $\mu$ P from Novix Inc (Cupertino, CA); an enhanced version of the Novix  $\mu$ P is also available as a standard cell from Harris Semiconductor (Melbourne, FL). This  $\mu$ P executes common Forth words in a single cycle. Further, it has no instruction queue, and it can also jump to an interrupt routine in a single processor cycle. The chip's architecture thus makes context switches and interrupt handling very fast.

#### **At the heart, a kernel**

At the heart of every real-time operating system except PolyForth is a real-time kernel. The kernel is a small set of programs that schedule tasks, manage resources, and provide mechanisms for intertask communication and synchronization (the Forth kernel exe-

cutes Forth). The kernel provides the mechanisms that you use to set up your system. It provides the means; you set the policy. For example, if the kernel has a prioritized scheduling mechanism, you set policy by assigning priorities to your individual tasks.

### Protection or lack thereof

If a real-time operating system's kernel is to have high performance, then it must assume that the tasks you have written are correct. Otherwise, if your tasks can't be trusted to confine their reads and writes to authorized areas of memory and to pass properly defined parameters, the real-time operating system's kernel will have to spend extra time doing error checking and parameter validation.

Real-time operating systems' kernels also do not do exception or error handling. If one of your tasks requests a service call that the real-time operating system's kernel can't execute, the kernel will simply return an error code. Your tasks must be prepared to decipher these error codes and take appropriate action.

### Semaphores

Real-time operating systems do provide a host of special function calls. The simplest, in theory at least, is the semaphore. A semaphore is a simple software mechanism for granting control of a shared resource to one task at a time. Conceptually, the classical semaphore is a counter with a queue attached. Tasks can perform only two operations—Signal and Wait—on a canonical semaphore. A Signal increments the counter and a Wait decrements it. If the counter's value is zero, any and all tasks performing a Wait join the queue and actually begin waiting until enough Signal operations occur to flush the waiting tasks from the semaphore's queue. Semaphore operations are good examples of critical regions. Some real-time systems use the classical semaphore; others have embellished it considerably.

Sometimes, a semaphore is implemented as a memory location or variable that contains a "token" only when the resource is available. The token functions as the key to a hotel room does. A task wanting to use the resource first must check the semaphore (or signal it, depending on which real-time operating system you use) either by reading the variable or by doing a system call to see if the token is available. (In the case of an operating-system call, the operating system functions as a hotel desk clerk, handing out keys and checking tasks in and out.)

If the task gets the token, it can use the resource. If

no token is available, the task can wait or do other processing until it gets the token. Simple systems require the blocked task to wake up repeatedly and poll the semaphore. More-sophisticated systems allow a task to put itself to sleep pending a wake-up call from the operating system. When finished with the shared resource, the task must return the token to the variable or to the operating system, as appropriate.

Microware Systems Corp's OS-9 has an extension to the classical semaphore that the firm calls an Event. The Event accepts the basic Signal and Wait commands of the classical semaphore; tasks can queue up in FIFO buffers while awaiting a blocked semaphore. Further, the Event has a counter just like a semaphore's. A successful signal-function call will cause the counter to count up by a fixed increment (you specify the increment when you set up the event). A successful Wait function call will reduce the counter's count by the specified increment.

The purpose of the counter becomes clear when you learn that the Wait function call requires an argument specifying a range for this event counter over which the Wait call will activate a given sleeping task. That is, after a successful signal call, the operating system will search the Wait queue and activate *all* waiting tasks whose prespecified range encompasses the new value for the event count. Thus, the Event resource can launch multiple tasks with one Signal.

Variations of the basic Signal call can jam a value into the event counter, increment it by a value other than the value fixed when the event was set up, or change the event counter's value temporarily (for one function-call cycle). This powerful, extended semaphore endows OS-9 with subtle intertask synchronization properties that experienced users can exploit creatively.

The exact nature of the token is not relevant to understanding the mutual-exclusion mechanisms. Operating-system designers have made use of the token differently. For example, Forth programmers use a zero as a token; if a task finds nothing in the mutual-exclusion location, then it writes its task-identification number into the location to take possession of the shared resource. If another task polls the location while the first task is in control of the shared resource, the polling task will not only know that the shared resource is busy, but will know which task is using it.

Digital Resources's FlexOS has an unusual, complex, and powerful meaning attached to the value of a token. When a task executes any FlexOS system call that could be followed by a Wait operation, the OS returns a 32-bit

*Text continued on pg 126*

## Glossary of real-time-software terms

Programmers sometimes use old words in different ways, coin words, or—confusingly enough—use several different words to describe what's more or less the same thing. For example, "exchange," "port," "channel," "socket," and "message" are all synonyms for "mailbox." The following glossary explains some commonly used real-time-software terms.

**Activity**—Synonym for *task*.

**CASE**—Computer-aided software engineering.

**Context switch**—A context switch occurs when, in a fashion similar to a subroutine call and return, one program is frozen and everything important to that program is stored in main or off-line memory: usually  $\mu$ P registers and pointers to private data structures (and coprocessor registers). Next, another program's registers and pointers are loaded into the  $\mu$ P. In some multi-tasking systems, an entire program and its attendant data structures are overlaid in core memory from off-line memory (real-time programs can't generally tolerate such overhead; consequently, for real-time systems, all *tasks*, running or suspended, usually reside in RAM). And finally, execution of the second program begins, starting at the location pointed to by the restored program counter.

**Critical region**—Any sequential segment of a program's code that can't tolerate interruption. Generally, a *task* must bracket the critical region with a pair of system calls to first lock out, and when finished, enable, operating-system interrupts. If you want your system to continue to answer external interrupts while a task is in a critical region, make sure that your interrupt-

service routine is not able to corrupt any processing that any task may have undertaken while in any critical region.

**Deadlock**—A condition in which each of two tasks waits for the other indefinitely. Deadlock results when two *tasks* attempt to control the same two *resources* at once. Each task can be in possession of one resource while waiting for the other task to release the other resource; thus, the tasks will wait forever.

**De-reference**—Etymologically unsound (compare to "delouse," for example) but useful neologism current among C programmers; it signifies retrieving an object pointed to by a pointer as opposed to directly referencing the pointer itself.

**Event**—Term used by Micro-ware's OS-9 for a semaphore having some special extensions to the canonical *semaphore*. More generally, an event is anything that stimulates a program and eventually results in a *context switch*.

**FIFO**—First in, first out. Taken in strict order of arrival.

**Hook**—The means whereby you can add your own code to an operating system. A simple form of hook is a Jump from the operating system's ROM to a RAM location. If you don't use the hook, you must initialize the RAM location with a Jump right back into the next location after the hook in the operating system's ROM. If you use the hook, you simply start your code at the destination of the hook's Jump command and eventually Return to the operating system's ROM upon completion of your addition.

**Kernel**—A kernel can be loosely defined as the bare-minimum skeleton of an operating system

that can sustain real-time multi-tasking. A kernel usually includes simple I/O calls, a context switcher, a system-timer task, and *mutual-exclusion* mechanisms. It doesn't usually include file I/O, a debugger, complex I/O such as local-area networks, or any program-development aids.

**Library/libraries**—An ambiguous term that can refer, in either singular or plural form, to either an entire library of programs or a program from a library. Presumably, "library program" was shortened to "library" just as "peripheral device" was shortened to "peripheral." The terms lead to such confusing utterances as: "You take the libraries from the appropriate library and include them as needed."

**Logical**—As used by programmers, the term is a synonym of "virtual"; it refers to the opposite of "physical" or "real," not the opposite of "illogical." It denotes the way a program interprets something as opposed to the thing's physical reality in the system's hardware. For example, a program running in a memory-management system may think it begins execution at address zero when, actually, it doesn't: The memory-management hardware adds an offset to the logical address to produce the real, or physical address in memory. The OS-9 manual provides an example of the way programmers use the term: "Because all OS-9 files have the same physical organization, file-manipulation utilities can generally be used on any file regardless of its logical usage . . . text file, executable program-module file, data file, [or] directory."

**Mailbox**—A secure mechanism, or *object*, for communication be-

tween asynchronous tasks. More than just a simple shared memory area, a mailbox has a *mutual-exclusion* protocol which keeps more than one *task* from accessing the mailbox at one time. Many mailboxes have message-deposit and message-wait queues attached to their mutual-exclusion protocols that allow multiple readers and writers to queue up and wait at a mailbox. Some even accept a stack of messages.

**Maintenance**—That portion of the software design and debugging process that continues after the program gets shipped to a paying customer (as opposed to a beta-site customer).

**Mutual exclusion**—Allowing only one *task* to have access to a shared *resource*—either a physical device or a data structure—at any given time. Mutual-exclusion mechanisms can also protect non-reentrant code and make it a serially reusable resource.

**Object**—An abstract software-engineering concept. An object is the combination of a data structure and the program needed to manipulate the data structure, considered as a unit. An array created by the DIM command is an example of an object. External routines have no control over the object's code, and they can't manipulate its data structures directly. *Mailboxes*, *semaphores*, arrays, variables, and even *tasks* are all objects.

#### **Object-oriented programming**

—A programming style said to make large complex programs manageable. Each data structure, along with its associated code, gets partitioned off from the rest of your program and becomes an *object*. You attempt to hide as much as possible of the

internal working of each of these objects from the rest of the program. Also, you should strive to make the interface for all your objects as uniform and simple as possible.

**Pipe**—Unix name for a large FIFO buffer masquerading as a pair of files. Asynchronous *tasks* can communicate large amounts of data through a pipe. The task writing to the tail of the FIFO buffer thinks it's writing into a file; similarly, the task reading from the head of the FIFO buffer thinks it's reading from a file. Actually, the pipe is usually a memory buffer. So that programmers need only master one set of I/O commands, elaborate operating systems such as Unix disguise this form, and all other forms of I/O, as read and write operations to files.

**Pre-emptive**—A pre-emptive *resource* services requesters in order of their priority, not their arrival.

**Primitive**—Synonym for service call or function call to the real-time operating system *kernel*.

**Process**—Synonym for *task*.

**Re-entrant code**—A program segment that does not modify itself locally. Because any number of asynchronous *tasks* can use this segment without interfering with each other, re-entrant coding helps make a real-time system compact.

**Resource**—Defined loosely, a resource can be any physical device, data structure, or mechanism for intertask communication or synchronization that the operating system manages (and perhaps guards from blundering or malicious programs).

**Semaphore**—A simple software mechanism for granting control of a shared *resource* to one *task*

at a time.

**Supervisor**—An ambiguous term. Some operating systems distinguish between the *kernel* and the supervisor (which sometimes includes the kernel). The kernel handles *task* scheduling while the supervisor handles I/O. Others use the term "supervisor" to refer to the portion of the kernel that schedules tasks.

**Task**—An abstract software-engineering concept. A task is an autonomous, asynchronous program that thinks it's running all by itself. How you divide a given software system into tasks is purely arbitrary.

**Time slicing**—The *supervisor* in a real-time operating system *kernel*, in response to a system-clock interrupt, deals out a defined segment of CPU time to a series of *tasks* in round-robin fashion. Pre-emptive schedulers generally do round-robin time slicing when a system has several ready-to-run tasks all at the same priority level.

**Unit**—An Intel iRMX term for the *token* that a *semaphore* returns to a calling *task* to indicate that the task has possession of the semaphore. Intel reserves the term "token" for the pointer that a calling task gets from the operating system after successfully acquiring an iRMX *object*. The distinction is that the unit's content has a meaning only for the operating system and not for the calling task; the task merely keeps the unit temporarily and returns it to the operating system when it's finished with the semaphore. On the other hand, the calling task uses the iRMX token to both take control of, and find, the iRMX object.

**Virtual**—Synonym of *logical*.

token to the calling task. The token has only one of the 32 bits set—in other words, it's a 1-bit bit mask.

The task does not know or care just which bit, of the 32 available, the operating system has set for that particular call. However, the operating system does keep track of which bit is set in each token possessed by each task. A given task can make as many as 31 requests, logically OR all of the tokens together, and pass the resulting bit mask to an operating-system Wait call. Note that the task does not simply take the token and begin using the resource. It must make an explicit Wait call. If the resource is available, the operating system will wake up the task immediately after the task makes its Wait call.

The power of this mechanism is the flexibility it gives you to suspend a task. Most real-time operating systems allow a task to wait for only two things at once: an event or a timeout (the event can be an unblocked resource, a message arrival, or an interrupt). A FlexOS task can wait for the first of 31 events to occur. The operating system also provides a software-interrupt mechanism for the cases in which the bit-map token approach proves cumbersome and time consuming.

### **Semaphores have three kinds of queues**

Intel's iRMX semaphores can have more than one token available if the shared resource has more than one unit available. You could use such multiple-token semaphores to regulate a producer-consumer relationship of, for example, a memory pool having several buffers within it.

Intel's iRMX semaphores have further embellishments. Three different kinds of queues are attached to each semaphore. Tasks that find themselves blocked when they try to use a resource guarded by a semaphore can wait in a FIFO queue or a prioritized queue (the task with the highest priority goes to the head of the queue even if it was the most recent one to join). Further, iRMX semaphores include a unique prioritized mechanism that the firm calls a Region.

Regions are not, in Intel terminology, areas of memory. Rather, they are prioritized semaphores with special properties. Regions have only one token to give. While a given task has the Region's token and is in control of the shared resource, the task's priority can change dynamically. After the task gives up the token, its priority returns to its predefined level. The task holding the token has its priority raised to the level of the *highest-priority* task waiting in the queue for the Region.

The reasoning behind this seemingly arcane mechanism is simple if you consider the following example: Suppose a low-priority task gets control of the resource guarded by the Region. Next, while the resource is blocked, a high-priority task joins the Region's queue and waits for the low-priority task to give up the token. But before the low-priority task can finish using the resource, it gets pre-empted by a medium-priority task that is not waiting in the Region's queue.

In effect, the medium-priority task has blocked the high-priority task because the low-priority task can't run to completion. The Region mechanism owes its existence to this subtle but troublesome problem, which, unfortunately, is only one of many subtle problems that arise from even as seemingly straightforward and simple a real-time mechanism as a semaphore.

### **Deadlock and how to avoid it**

The most commonly cited problem you might incur when coordinating multiple tasks with semaphores is deadlock, a condition in which each of two tasks waits for the other indefinitely. You risk deadlock if you allow your tasks to attempt to control more than one resource at a time. Imagine that you have two tasks and two shared resources. Each task captures control of one of the two resources. Then each task attempts to acquire the resource the other task controls. Failing to gain control, one task puts itself to sleep to await its turn at the resources the other task controls.

However, the other task will also fail in its attempt to gain control of the resource that the first task controls. Because it's blocked and asleep, the first task will never release its resource. Therefore, the second task has no choice but to put itself to sleep to await the release of the other resource. Both tasks are blocked forever unless you set a timeout before requesting resources. Even if you have set a timeout, your tasks must still resolve the deadlock when they wake up from their unsuccessful attempts to get the resources.

If you have no choice except to allow your tasks to control multiple resources, you can avoid deadlock by requiring tasks to request and release these resources in the same sequence and by dynamically adjusting the controlling task's priority in a fashion similar to Intel's Region. In other words, order your shared resources and assign them a number. Then, you must enforce the following discipline: Tasks must request control of the resources in ascending order and release them in descending order. That way, a task will be able to gain control of either an entire group of resources or none at

# Readers Endorse Clearpoint's Designer's Guide

"A good refresher text for highly technical professionals, as well as an excellent introduction for the broader requirements of technicians and purchasing departments."

R.B. Guppy  
Senior Electrical Engineer  
KALIUM CHEMICAL  
A Division of PPG Canada Inc.

"The Designer's Guide is perfect for someone who understands the basics but needs essential information to make decisions. Congratulations on a very objective presentation."

Christopher M. Kreager  
Systems Specialist  
UNITED DATA SYSTEMS

"We have made a lot of use of the Designer's Guide at Logicon. As software developers, we were most interested in the sections on reliability. I absolutely recommend it."

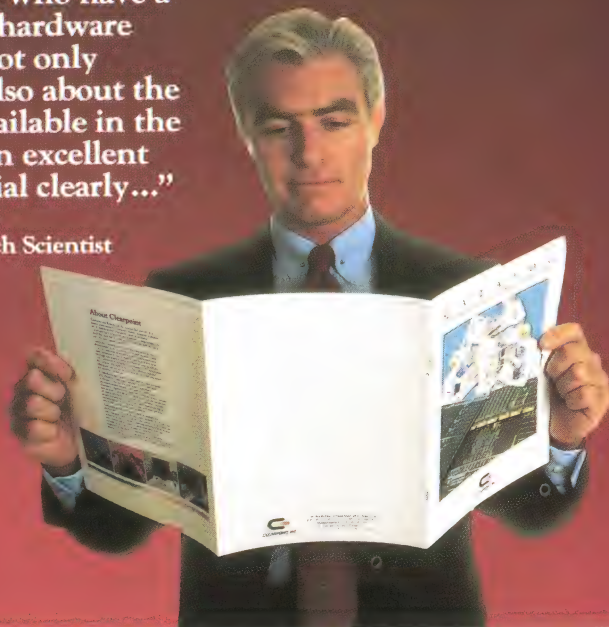
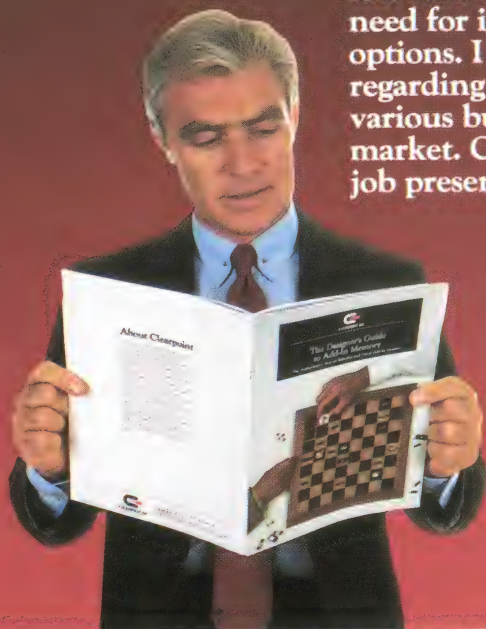
Robert N. Mellott  
Technical Staff Member  
LOGICON

"Tremendously interesting... I understood everything. The section on the VAXBI clearly explained why it is different from the other buses, without unnecessary or boring detail. Next time send 6 or 8 copies."

Steve Waddell  
Software Training Consultant  
SOUTH CENTRAL BELL  
Advanced Systems, Inc.

"I especially recommend it for software technical people who have a need for information on hardware options. I learned a lot, not only regarding memory, but also about the various bus structures available in the market. Clearpoint did an excellent job presenting the material clearly..."

Carl F. Billhardt  
Principal Research Scientist  
BATTELLE



## FREE: The 1987-88 Edition of Clearpoint's Designer's Guide to Add-in Memory and Product/Service Catalog

### The New Designer's Guide to Add-in Memory

is the authoritative reference for buyers with a need to know. It is clearly written for a broad range of reader requirements, from the very technical to the purely management-oriented. Find out why readers everywhere rave about the Designer's Guide—an objective source book that tells you how to find the best in performance, reliability and value.

The updated 1987-88 edition includes important new information on the buses appearing today: ■ the proliferation of new DEC machines ■ where to find the best price/performance for memory ■ an expanded survey of the performance and memory options available in the IBM line, from the PS/2 Micro Channel to the 9370 ■ What the HP 9000 offers users ■ MIPS and megabytes for the new Sun 4/2XX and Apollo DN 4000 ■ and much, much more.



**CLEARPOINT INC.**

99 South Street • Hopkinton, MA 01748-2204  
U.S.A. 1-800-CLEARPT Telex: 298281 CLEARPOINT UR  
Massachusetts 617-435-5395/435-2301  
Europe: Clearpoint Europe b.v.  
Tel: 31-23-273744 Telex: 71080 CLPT NL  
Canada: Clearpoint Canada Tel: 416-620-7242  
Japan: Clearpoint Asia  
Tel: 03-221-9726 Telex: 32384

### The New Clearpoint Catalog of Memory Products & Technical Support Services

is a colorful and comprehensive technical brochure presenting the full spectrum of Clearpoint products, manufacturing procedures, customer support services, and specifications.

- The DEC-compatible products include: MicroVAX II, the complete VAX 8000 Series, VAX 780 and 750, Unibus, PMI-Bus, and Q-Bus.
- Other high performance memory: VMEbus, IBM PC/RT, VERSAbus, Sun, and Apollo.
- Non-Memory products: Liberty Board, TurboDisk, and TurboDisk-Plus.

**Write or Call for Your Free Copies**

DEC, MicroVAX II, VAX, PMI-Bus, Q-Bus, are all registered trademarks of Digital Equipment Corporation.  
IBM PC/RT and PS/2 Micro Channel are registered trademarks of International Business Machine Corporation.  
Sun is a trademark of Sun Microsystems.  
Apollo is a trademark of Apollo Computer.  
Liberty is a trademark of Trimarchi, Inc.  
TurboDisk and TurboDisk-Plus are trademarks of EEC Systems.  
VERSAbus is a trademark of Motorola.  
HP is a trademark of Hewlett Packard.

---

*The most commonly cited problem you might incur when coordinating multiple tasks is deadlock.*

---

all. And because the controlling task's priority is momentarily adjusted up to the level of the highest-priority task that's waiting for the group of resources, lower-level tasks will not be able to block the waiting high-level task.

Semaphores allow independent tasks to share non-reentrant resources safely. Tasks could communicate by placing messages in a shared memory area protected by a semaphore. But most real-time operating systems have a special mechanism, called a mailbox, for passing short messages.

#### **Mailboxes let tasks pass messages to each other**

A mailbox is a software entity, normally controlled by a real-time operating system, for passing messages between tasks or between tasks and interrupt handlers. You can think of a mailbox as an extremely shallow FIFO buffer—so shallow that it holds only one item. You need mailboxes when you send messages between asynchronous tasks. The writing task posts a message to a mailbox whenever it needs to. Similarly, the reading task attempts to get the message out of the mailbox at a time appropriate for its program sequence. Naturally, the operating system must provide for mutual exclusion to ensure that the two tasks do not try to access the mailbox simultaneously.

Real-time-software engineers often employ mailboxes in pairs to effect a software simulation of a 2-wire handshake: The posting task uses one mailbox to send a message, and the receiving task uses another mailbox to acknowledge receipt of the message.

Also, if the reading task has not yet picked up the message previously posted by the writing task, the operating system must return an error code to the writing task. In other words, the writing task needs to know that its letter was picked up before it posts another message. Similarly, if the mailbox is empty, the reading task must get an error code so that it can go to sleep to await the receipt of a message. The mailbox can thus synchronize communication between asynchronous tasks.

Intel's iRMX extends the notion of the mailbox by incorporating three queues: a message queue, a writing-task queue, and a reading-task queue. Of course, the task-waiting queues can be either FIFO queues or prioritized queues.

Simple descriptions of how real-time operating systems' primitives work do not do justice to them. To use these primitives (such as mutual-exclusion mechanisms), a software engineer must adopt a mindset

entirely different from the one he uses for sequential programming.

To get an idea of just how different multitasking programming is from sequential programming, consider the four examples discussed in the following section. The examples show the coding of four different schemes for granting reading and writing privileges to a common data area or file. The examples are taken from Andyne Computing Ltd's PC Mascot manual, which provides many more such examples. PC Mascot is an implementation for the IBM PC of the Mascot real-time operating system (Ref 5).

One peculiarity of Mascot needs to be explained before you can understand the examples: Mascot combines the notion of a mutual-exclusion queue with that of a mailbox. A task can join a queue. The operating system will suspend the task until it reaches the head of the queue. Once at the head of the queue, the task awakens and owns the queue until it explicitly leaves the queue (even the task's going to sleep does not release the queue).


While it's in possession of the head of a queue, and only in that state, a task can wait on the queue. That is, the task suspends itself and will awaken only when another task stimulates the queue. Obviously, no other task can take possession of the head of the queue until the waiting task is awakened and decides to leave the queue.

To flesh out these examples with another real-time operating system, you would have to coordinate a semaphore and a mailbox. That is, a task would first have to request a semaphore. When it acquires the semaphore, it then must request a read from a mailbox—and perhaps wait for a message to be deposited in the mailbox. After a successful read, the task finally surrenders the semaphore.

The problem these examples solve is the general "readers and writers" problem. The solutions must satisfy two conditions: Any number of readers can simultaneously access the data, but any writer must have exclusive access to the data (there can be only one writer at a time). That way, readers need not be concerned that the data will mysteriously change as they are reading it (remember, each task in a multitasking system is under the delusion that it alone is running).

The four strategies for establishing precedence are:

- Taking readers and writers in strict order of arrival. Once a writer is writing, all readers and writers are excluded; a batch of consecutive read-



# Loral Simplifies MIL-STD-1553 Testing

## ELIMINATE HIDDEN COSTS OF IN-HOUSE DESIGNS

If you're tired of trying "in-house solutions" to automate your production test requirements, the leader in MIL-STD-1553 test equipment has what you've been looking for.

Loral's new System 300/SBA automates your production testing without the software changes, learning curves, and support headaches of in-house test equipment. All your software and hardware needs are in an off-the-shelf system that automates:

- environmental stress testing

- factory acceptance testing
- real-time data bus simulation
- multiple bus analysis and monitoring

### Easy to use, ready to go.

Forget learning a new operating system or developing custom software from scratch. Our fully tested software is ready-to-run and packed with protocol test routines, including the anticipated Production Test Plan standard. Or use our self-prompting, advanced menu-driven software to write your own test programs. The System 300/SBA shortcuts

automatic, pinpoint testing to ensure your avionics are fault free.

### Flexible for your future needs.

The System 300's modular, flexible design means you buy only the capability you need now, and still expand your system easily in the future. Our competitive price includes the services of full-time 1553 applications engineers who assist with programs for your unique testing situation.

Automate production testing the simple way with the System 300's

- off-the-shelf hardware and software
- ease of programming
- applications support
- flexibility
- modularity

Call us at **1-800-351-8483, ext. 300** (1-619-560-5888, ext. 300) to hear how the System 300/SBA can simplify production test automation. We're at 8401 Aero Drive, San Diego, California 92123-1720.

# LORAL

Instrumentation

*Using mutual-exclusion mechanisms requires a software engineer to adopt a mindset entirely different from the one he uses for sequential programming.*

```

control queues:  mutex
                 read_count_cq

ida layout:      read_count
                 data_record

start_read ()
{
    JOIN mutex
    JOIN read_count_cq
    read_count++
    LEAVE read_count_cq
    LEAVE mutex
}

end_read ()
{
    JOIN read_count_cq
    read_count--
    If (read_count == 0)
    {
        STIM mutex
    }
    LEAVE read_count_cq
}

start_write ()
{
    JOIN mutex
    while (read_count > 0)
    {
        WAIT mutex
    }
}

end_write ()
{
    LEAVE mutex
}

```

**Fig 1**—These entry and exit routines accommodate readers and writers in strict sequence of arrival. Tasks gain entry to reading and writing routines (not shown here) by joining mutual-exclusion queues. Tasks sort out precedence, here and in **Figs 2, 3, and 4** by keeping count of readers and writers and posting messages (STIM) to tasks waiting on queues.

ers has unrestricted access until the next writer arrives.

- Giving readers precedence over writers. Waiting readers have access before waiting writers do.
- Giving writers precedence over readers. Waiting writers have access before waiting readers do.
- Dividing readers into two classes: high-priority readers that have precedence over writers, and low-priority readers, over which writers have precedence.

The Mascot queues, by their nature, give requesting tasks strict FIFO access. Some other real-time operating systems, such as Intel's iRMX, would give you the option of prioritizing their semaphore and mailbox queues.

The examples in **Figs 1** through **4** consist of two pairs of simple routines that reading and writing tasks must call before and after doing a read or write. The examples are written in a C-like pseudolanguage and are

stripped of many implementation details. The actual data manipulation in the shared-data area is application dependent and is not germane to these examples. Each of the examples begins with a declaration of mutual-exclusion control queues. Note that the "ida" (intercommunication data area) declaration in the program header is simply a declaration of the data constructs and variables that are local to these functions.

The routines in **Fig 1** fulfill the first strategy and accommodate readers and writers in the strict sequence of arrival. To understand the action of the two pairs of procedures in **Fig 1**, assume that no read or write requests are under way and that the first request is a read request. *Starread* increments *reacount* by one and allows the reader to proceed. All subsequent read requests, up to the first write request, will have the same effect. Now suppose that a write request occurs while a number of readers are currently reading. When the writer reaches the head of the *mutex* mutual-exclusion queue, it will block all further readers from initiating reads.

The writing task in possession of the *mutex* queue then goes to sleep to wait for the last reader to call *enread*. The last reader's calling *enread* will decrement *reacount* to zero and use the STIM system call to send a message to the writing task, which has been waiting for just such a message (remember, the queue functions as a mailbox for the task at the head of the queue). The writing task then updates the common data area and finally exits through *enwrite*, releasing the *mutex* mutual-exclusion queue, and allowing other readers and writers their turn to proceed.

**Fig 2** is the same two pairs of read- and write-access-control routines modified to allow readers precedence over writers. When you compare **Fig 2** with **Fig 1**, you'll note that the listing in **Fig 2** has an additional control queue, *writcq*, in which tasks waiting to write must queue up. Note the cause and effect here: Giving readers precedence over writers means that writers, not readers, must queue up.

*Starread* is exactly the same in **Fig 2** as it is in **Fig 1**. *Enread* is almost identical—the only change is that the routine must now stimulate *writcq* when *reacount* becomes zero instead of *mutex*. The *starwrite* procedure is quite different because a writing task must first join the queue of waiting writers.

After reaching the head of the queue of writers, it must then wait until no more readers are reading. This situation is an example of a case in which you must exercise extreme care when setting up mutual-exclu-

# Some of the best reasons for buying an Archimedes C Compiler have nothing to do with its amazing speed

*Speed is one thing. But most programmers like the way Archimedes ANSI-C runs and debugs generic C-code with host C-compilers and debuggers, like Microsoft's C-86 and CodeView®*

*Writing your own library routines can be frustrating. Except with Archimedes, which supports advanced math functions and lets you skip writing your own routines.*

*Compatibility with standard equipment means a great deal to those making purchasing decisions. Tell them that Archimedes runs on hosts like the IBM PC, MicroVAX and VAX systems.*

*Another reason to use C instead of assembly: You can easily update code, even if you're not the original programmer.*

*Archimedes also takes the trouble out of big projects: You can easily integrate code from several programmers via a special LINT-type feature.*

*Even the fastest programming language can be made faster if the code is reusable for other microcontrollers. And Archimedes is.*

*Speed is useless if you can't apply it to your favorite microcontrollers. And Archimedes supports the most popular: Intel 8051 and 8096 families, Motorola 68HC11 and 6801, Zilog Z80, Hitachi 6301 and HD64180, and more.*



As you can see, there are many advantages of programming microcontrollers in C other than speed. But when it gets right down to it, speed is why you'll buy Archimedes Microcontroller C. Because C-Code is cleaner, clearer, easier to use—and using it is guaranteed to cut your development time by at least 50% over assembly.

Call Archimedes now at (415) 567-4010 for a free demo diskette and product guide on Archimedes Microcontroller C. So you can hurry up and start programming faster than ever.

© 1987 Archimedes Software, Inc. Archimedes and Microcontroller C are trademarks of Archimedes Software, Inc. MicroVAX and VAX are registered trademarks of Digital Equipment Corp. IBM is a registered trademark of International Business Machines. CodeView and Microsoft are registered trademarks of Microsoft Corp.



Archimedes Software Inc.  
2159 Union Street  
San Francisco, CA 94123

TM

```

control queues: mutex
                read_count_cq
                write_cq

ida layout:     read_count
                data_record

start_read ()
{
    JOIN mutex
    JOIN read_count_cq
    read_count++
    LEAVE read_count_cq
    LEAVE mutex
}

end_read ()
{
    JOIN read_count_cq
    read_count--
    If (read_count == 0)
    {
        STIM write_cq
    }
    LEAVE read_count_cq
}

start_write ()
{
    JOIN write_cq
    JOIN mutex
    while (read_count > 0)
    {
        LEAVE mutex
        WAIT write_cq
        JOIN mutex
    }
}

end_write ()
{
    LEAVE mutex
    LEAVE write_cq
}

```

*Fig 2—Somewhat similarly to those of Fig 1, these read- and write-access-control routines allow readers precedence over writers.*

sion mechanisms. The writing task that has reached the head of the writers' queue, and is checking to see whether any active readers are left, must first gain control of the mutual-exclusion queue *mutex* before checking the *readcount* variable. If the writing task weren't preventing reading tasks from initiating a read during the interval in which the writing task was checking for readers, a reading task could overtake the writing task.

Now you have the explanation for the clumsy-looking series of LEAVE and JOIN function calls that bracket the writing task's WAIT function call (the task is waiting for a message from the last exiting reading task). The writing task must gain control of the mutual-exclusion queue *mutex* to check on readers, but must leave it so that readers can continue to read the resource as long as they wish—thus fulfilling the second scheme's requirements.

```

control queues: mutex
                read_cq
                read_count_cq
                write_count_cq

ida layout:     read_count
                write_count
                data_record

start_read ()
{
    JOIN read_cq
    JOIN mutex
    while (write_count > 0)
    {
        LEAVE mutex
        WAIT read_cq
        JOIN mutex
    }
    JOIN read_count_cq
    read_count++
    LEAVE read_count_cq
    LEAVE mutex
    LEAVE read_cq
}

end_read ()
{
    JOIN read_count_cq
    read_count--
    If (read_count == 0)
    {
        STIM mutex
    }
    LEAVE read_count_cq
}

start_write ()
{
    JOIN write_count_cq
    write_count++
    LEAVE write_count_cq
    JOIN mutex
    while (read_count > 0)
    {
        WAIT mutex
    }
}

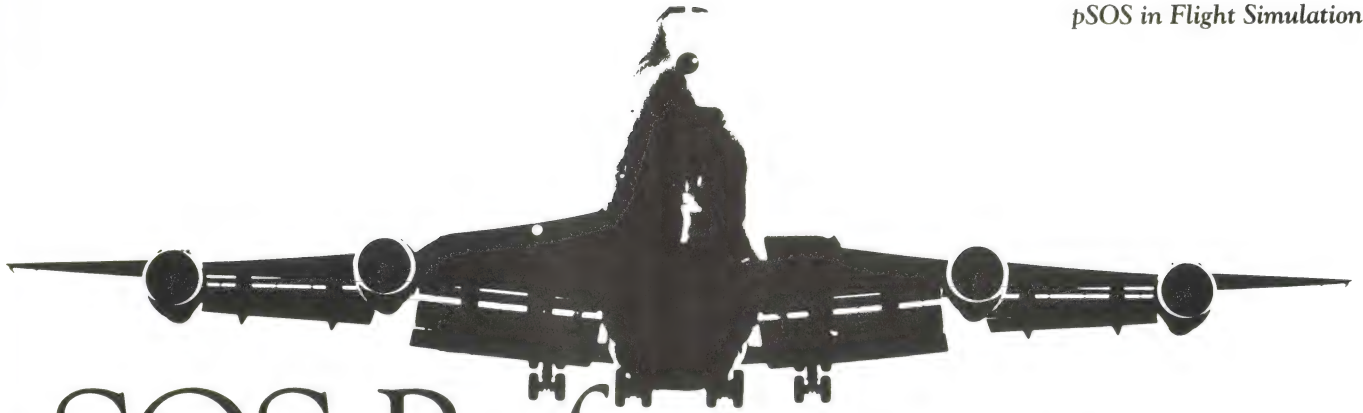
end_write ()
{
    JOIN write_count_cq
    write_count--
    If (write_count == 0)
    {
        STIM read_cq
    }
    LEAVE write_count_cq
    LEAVE mutex
}

```

*Fig 3—These routines give writers precedence over readers.*

The third example, in Fig 3, gives writers precedence over readers. As in Fig 2's listing, in Fig 3 a control queue for tasks waiting to read, *readcq*, replaces the previous queue for tasks waiting to write. Also new to this schema is a counter (*writcount*) for the number of writers waiting to write, and a mutual-exclusion queue (*writcountcq*) to protect it.

In a fashion similar to the writing routine of Fig 2's example, a reader first joins the read queue *readcq* and then, after reaching the head of the queue, waits for a message from the final writer that all writers are



# pSOS Performance Helps Boeing Fly Instrumentation Before It's Built

**P**erformance. Raw, blinding performance. In the world's most advanced engineering simulation laboratory, Boeing has created an environment in which pilots can prove and improve the design of new flight deck instrumentation. But if the system doesn't run in real-time, it might as well be grounded.

Which is why the Boeing Flight Simulation Lab has standardized on pSOS™ real-time engines to interface multiple, high-speed, simulation processors to aircraft flight instrumentation. Whether it's the Digital DataBus or DATAC ARINC 629 standard, pSOS is now the Boeing Flight Simulation Lab standard.

Sure, other factors influenced Boeing Flight Simulation Lab's adoption of pSOS. The pUCP™ multiprocessor system managers erase boundaries between processors. So pSOS and UNIX tasks can interact with each other without caring which processor they are running on. Or how many. Seamlessly. Which is vitally important for driving clusters of precision instruments. And the pPROBE™ system analyzer accelerates debugging in this hybrid environment.

But the factor that distinguishes the pSOS family of real-time engines is performance. Rock-solid, proven, reliable, benchmarked performance. And the factor that distinguishes pSOS customers is success.



## WRITE TODAY. FLY TOMORROW.

Attached is my business card or letterhead. I'm doing 32-bit real-time development and performance is important.

- ☐ Have a sales engineer give me a call.
- ☐ Let me know when you'll be holding a free seminar in my area. I'd like to attend.



4655 Old Ironsides Drive • Santa Clara, CA 95054  
(408) 727-0707 • Telex: 757697 (SoftCom)

Once they're written, all real-time systems require extensive debugging and fine-tuning.

```

control queues: mutex
                read_cq
                read_count_cq
                write_cq
                write_count_cq

ida layout:     read_count
                write_count
                data_record

start_hp_read ()
{
    JOIN mutex
    JOIN read_count_cq
    read_count++
    LEAVE read_count_cq
    LEAVE mutex
}

end_hp_read ()
{
    JOIN read_count_cq
    read_count--
    If (read_count == 0)
    {
        STIM write_cq
    }
    LEAVE read_count_cq
}

start_write ()
{
    JOIN write_count_cq
    write_count++
    LEAVE write_count_cq
    JOIN write_cq
    JOIN mutex
    while (read_count > 0)
    {
        LEAVE mutex
        WAIT write_cq
        JOIN mutex
    }
}

end_write ()

{
    JOIN write_count_cq
    write_count--
    If (write_count == 0)
    {
        STIM read_cq
    }
    LEAVE write_count_cq
    LEAVE mutex
    LEAVE write_cq
}

start_lp_read ()
{
    JOIN read_cq
    JOIN mutex
    while (write_count > 0)
    {
        LEAVE mutex
        WAIT read_cq
        JOIN mutex
    }
    JOIN read_count_cq
    read_count++
    LEAVE read_count_cq
    LEAVE mutex
    LEAVE read_cq
}

end_lp_read ()
{
    JOIN read_count_cq
    read_count--
    If (read_count == 0)
    {
        STIM write_cq
    }
    LEAVE read_count_cq
}

```

Fig 4—Using all the techniques developed in Figs 1, 2, and 3, these routines allow for two classes of readers: a high-priority class that takes precedence over readers and a low-priority class that doesn't.

finished. Note the similar sequence of getting and releasing the mutual-exclusion queue *mutex* while checking the variable *writcount*. *Writcount* is another classic example of a critical region that needs protection.

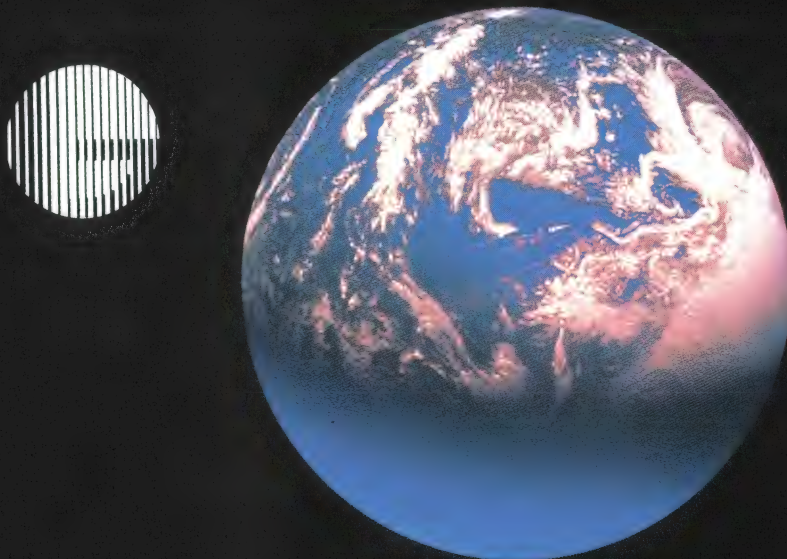
The read task still has more to do before it actually reads. It must get to the head of the queue that protects the variable holding the count of readers, and it must increment the count. The reader must lock out other tasks from the *reacount* variable because writing tasks use *reacount* for decision making—another critical region.

Reading tasks exit through *enread*. If a reading task is the last one to exit, it sends a message (via the STIM function call) to any waiting writing task. Writing tasks simply work their way to the head of the writing-task queue and increment the count of the number of writers kept in *writcount*. They then work their way to the head of the mutual-exclusion queue. Once at the head of the mutual-exclusion queue, they automatically block

any more read tasks from starting a read operation. When all the readers who were currently reading eventually finish, the writer gets a message posted at *mutex* by the last exiting reading task, and it begins writing. When exiting, the last writing task posts a message to the reading task (if one exists) that has been waiting for its turn.

The handshaking between reading and writing tasks is very subtle in this example. Readers can't proceed until all the writers are finished, and once one or more readers gets control of the common data area, writers must wait. Note the structure of the exclusion mechanisms that accomplish this handshaking. One mechanism, *mutex*, protects reads of two resources: *writcount* (by the reading task) and *reacount* (by the writing task). Yet reading and writing tasks have separate exclusion mechanisms, *reacountcq* and *writcountcq*, to protect writes to these same two resources (*reacount* and *writcount*). This example incisively illustrates the precision with which you must apply protection mecha-

# LEADING MANUFACTURERS RELY ON GENNUM IC's



## WORLDWIDE.

## WE DEVELOPED THE SCIENCE OF LISTENING

Listening to the needs of our customers has always been our philosophy at Gennum Corporation. That's the reason leading OEM's in Japan and 17 other countries listen to our experts.

For 15 years we have manufactured specialty linear IC's without compromise in quality or service. From masking and silicon diffusion to chip packaging, our products are produced inhouse, allowing us to monitor and maintain our high standards of excellence.

Our lineup of special application products includes high frequency power supply controller

IC's, AGC amplifiers and video switches. We are the leaders in applications requiring low power IC's like audio and operational amplifiers operating down to 1.0V.

Custom and semicustom play an important role in our business. Depending on your needs we can draw from our complete range of ASIC products and services.

We have developed an RF monolithic capability for applications up to 500 MHz, including high linearity amplifiers.

We would like to listen to **your** needs. Call or write for our free brochure.

P.O. Box 284  
Buffalo, N.Y.  
14220  
Toll Free: 1-800-263-9353



**GENNUM**  
CORPORATION

P.O. Box 489  
Station "A"  
Burlington, Ontario  
Canada L7R 3Y3  
(416) 632-2996  
Telex: 061-8525  
Fax: (416) 632-2055

CIRCLE NO 104

GENNUM CORPORATION IS AN ITI COMPANY

# Experience Counts.



## EZ-PRO Emulators

Experience quick delivery, easy operation, fast development schedules. EZ-PRO® users reap the benefits of the C language fully integrated with advanced emulation tools, including precedence triggering, Deep Trace™, on-line code revisions, and performance analysis tools.

In addition to IBM® PC-XT/AT, hosts include IBM Personal

System/2,™ Macintosh II,™ VAX,™ MicroVAX,™ and Sun Workstation.®

EZ-PRO users also have the advantage of the best post-sales support in the industry.

They know that their emulators are covered by

American Automation's 5-year limited warranty.

Experience counts. Now with over 10 years experience American Automation has designed more emulators than anyone. Count on EZ-PRO to provide the most cost/effective development support.

<b>Intel:</b> 8031 8032 8086 8035 8088 8039 80186 8344 80188 8048 80286 8049 8050 8051 8085A 8085A2 8096/97	<b>Motorola:</b> 6800 68B00 6801 6802 68B02 68000 146805E2 68008 68010 6808 68B08 6809 6809E 64180R0 64180R1	<b>Hitachi:</b> 6301R 6301V1 6301X 6301Y 6303R 6305V 63705 6309 6309E 6809 64180R0 64180R1	<b>Rockwell:</b> 6502 6503 6504 6505 6506 6507 6512 6513 6514 6515	<b>RCA:</b> 1802 1805 1806 CDP6805C4 CDP6805C8 CDP6805D2 CDP6805E3	<b>Zilog:</b> Z80A Z80B Z80H Z180 Z8001 Z8002
				<b>Harris:</b> 80C86 80C88	<b>NEC:</b> V20 V40 V30 V50
				<b>National:</b> NSC800	<b>Signetics:</b> 8X300 8X305

...AND MORE

\*Assumes EZ-PRO Development Station connected to MSDOS host.

**american automation**



2651 Dow Avenue, Tustin, California 92680 (714) 731-1661

FAX: 714/731-6344

IBM is a registered trademark of International Business Machines, VAX and MicroVAX are registered trademarks of Digital Equipment Corporation, Macintosh is a registered trademark of Apple Computer, Inc., Sun Workstation is a registered trademark of Sun Microsystems, Inc.

---

*Most real-time-software engineers pepper their code with extra routines that record information about a routine as it executes.*

---

nisms when dealing with asynchronous tasks.

The last example, Fig 4, allows for two classes of readers, high-priority readers (*starhread*) and low-priority readers (*starlread*). High-priority readers zip through their entry routine, pausing only long enough to increment the count of readers. In a similar fashion, the last exiting reader kicks off any waiting writing task by sending a message, via the *STIM* function call, to the *writcq* queue (which, as before, serves as first a queue and then a mailbox).

Writing tasks, in the course of writing, block any low-priority reading tasks, which must wait until all writers finish. Note, however, that even low-priority readers, once they get going, increment the *reacount* variable, just as high-priority readers do; they thus block any subsequent writers until all readers finish. By now, you should realize that to write routines such as these, you need a solid design and a thorough understanding of real-time-programming intricacies.

Once they're written, all real-time systems require

extensive debugging and fine-tuning. At present, no completely integrated hardware-and-software debugging tools are available (Ref 6). You can obtain hardware and software tools separately, of course. High-level-language debuggers are available in several forms, and you can get real-time-OS debuggers. You can also find logic analyzers, in-circuit emulators, and software-performance analyzers (Ref 7), which can identify software bugs that baffle software-based tools. But you can't obtain a single integrated package that can simultaneously control a high-level language debugger, an operating-system debugger, and hardware-based tools.

Consequently, most real-time-software engineers will probably fall back on tried-and-true techniques of "instrumenting" their code. That is, they will pepper the code with extra routines that record pertinent information about a routine as it executes. The classic example of this technique of instrumenting a program with additional statements is the practice of debugging

---

## Manufacturers of real-time operating systems

For more information on real-time operating systems, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

**Aleyon Corp**  
5010 Shoreham Pl  
San Diego, CA 92122  
(619) 587-1155  
TWX 510-600-4947  
Circle No 711

**Andyne Computing Ltd**  
544 Princess St, Suite 202  
Kingston, Ontario  
Canada K7L 1C7  
(613) 548-4355  
Circle No 712

**Avocet Systems Inc**  
Box 490  
Rockport, ME 04856  
(800) 448-8500  
(207) 236-9055  
Circle No 713

**Diab Systems Inc**  
323 Vintage Park Dr  
Foster City, CA 94404  
(415) 571-1700  
TLX 516020  
FAX (415) 573-7562  
Circle No 714

**Digital Research Inc**  
18600 Embarcadero Rd  
Suite 215  
Palo Alto, CA 94303  
(415) 856-4343  
FAX (415) 8567-2103  
Circle No 715

**Dyad Technology Corp**  
4040-G Sorrento Valley Blvd  
San Diego, CA 92121  
(619) 450-17861  
Circle No 716

**Eyring Research Institute Inc**  
145 West 820 North  
Provo, UT 84601  
(801) 375-2434  
Circle No 717

**Force Computers Inc**  
702 University Ave  
Los Gatos, CA 95030  
(408) 354-3410  
Circle No 718

**Forth Inc**  
111 N Sepulveda Blvd  
Manhattan Beach, CA 90266  
(213) 372-8493  
TLX (275)182  
Circle No 719

**Industrial Programming Inc**  
100 Jericho Quadrangle  
Jericho, NY 11753  
(516) 938-6600  
Circle No 720

**Integrated Solutions**  
1140 Ringwood Ct  
San Jose, CA 95131  
(408) 943-1902  
TLX 4996929  
Circle No 721

**Intel Corp**  
5200 NE Elam Young Parkway  
Hillsboro, OR 97124  
Phone local office  
Circle No 722

**Intelligent Machinery Co**  
2400 Westwood Dr  
Longwood, FL 32779  
(305) 869-8168  
Circle No 723

**JMI Software Consultants Inc**  
904 Sheble Lane  
Box 481  
Spring House, PA 19477  
(215) 628-0840  
Circle No 724

**Micro Computer Control**  
Box 275  
Hopewell, NJ 08525  
(609) 466-1751  
Circle No 725

**Microware Systems Corp**  
1900 NW 114th St  
Des Moines, IA 50322  
(515) 224-1929  
TWX 910-520-2535  
FAX 515-224-1352  
Circle No 726

**Ready Systems**  
Box 61029  
Palo Alto, CA 94306  
(415) 326-2950  
TLX 71510608  
FAX 415-326-1427  
Circle No 727

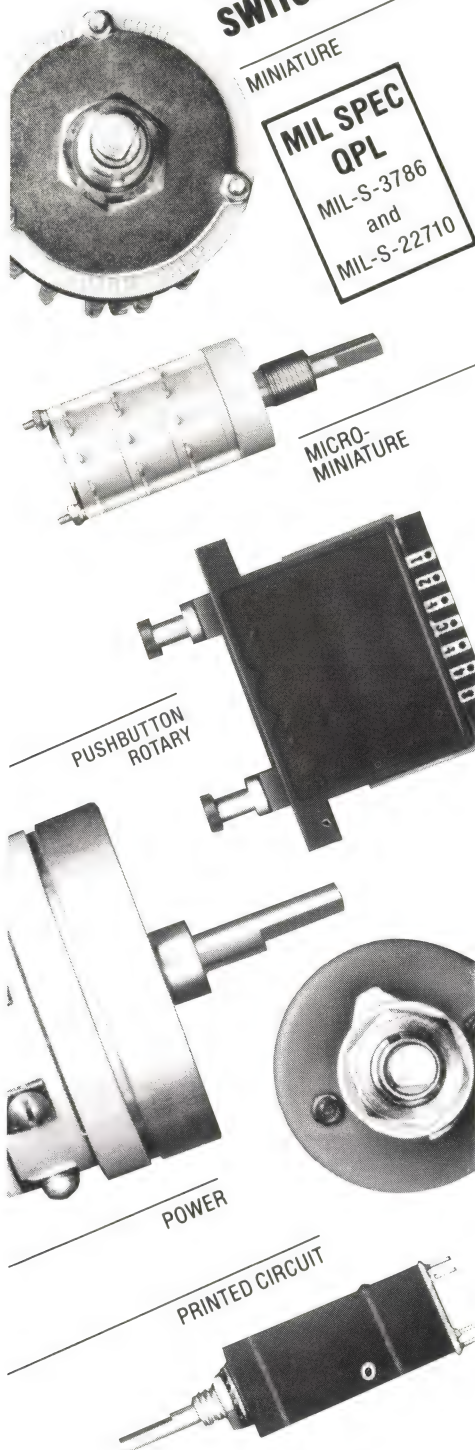
**Software Components Group**  
4655 Old Ironsides Dr  
Suite 370  
Santa Clara, CA 95054  
(408) 727-0707  
TLX 757697  
Circle No 728

**Systems & Software Inc**  
3303 Harbor Blvd, C-11  
Costa Mesa, CA 92626  
(714) 241-8650  
TWX 910-695-0215  
FAX (714) 241-0377  
Circle No 729

**US Software Corp**  
14215 NW Science Park Dr  
Portland, OR 97229  
(503) 641-8446  
TLX 4993875  
Circle No 730

# THE PROVEN PERFORMERS FOR 40 YEARS!

## JANCO ROTARY SWITCHES



**Janco**  
AN ESOP CORP.

3111 Winona Avenue, Burbank, CA 91504  
(818) 846-1800 • TWX: 910 4982701

CIRCLE NO 12

a Basic program by inserting extra Print statements throughout the program.

To instrument their code, real-time-software engineers would probably do something that's better suited to real-time systems. For example, they might equip each task with routines that record the system clock's value in a debugging array at critical points in each routine's execution—routine entry and exit points, for example. Such extra code obviously distorts the real-time performance of the system, but it provides a quick way of identifying routines that are hogging the CPU.

**EDN**

## References

1. Leibson, Steven H, "HLL cross compilers speed 1-chip- $\mu$ C software development" *EDN*, December 24, 1987, pg 126.
2. Fisher, W, *Selecting the right real-time operating system for VMEbus based systems*, Force Computers Inc, Los Gatos, CA, 1987.
3. Meyer, Bertrand, "Reusability: The case for object-oriented design," *IEEE Software*, March 1987.
4. *Methodologies & tools for real time systems: IV*, 1987, The National Institute for Software Quality and Productivity, Washington, DC.
5. *The official handbook of MASCOT*, March 1983, Computing Policy and Standards Section, Royal Signals and Radar Establishment, Malvern, UK.
6. Small, Charles H, "Debuggers help you perfect high-level and real-time code," *EDN*, December 10, 1987, pg 152.
7. Small, Charles H, "Logic analyzers evolve in response to high-level languages," *EDN*, February 6, 1986, pg 61.
8. Boehm, B, *Software Engineering Economics*, Prentice-Hall, Englewood Cliffs, NJ, 1981.
9. Boehm, B, McClearn, R, and Unfrig, D, "Some experiences with automated aids to the design of large scale reliable software," *IEEE Transactions on Software Engineering*, Vol SE-1, No 1, March 1975, pg 125.
10. "Using Ada in real-time applications," *Professional Program Session Record 6*, Mini/Micro Northeast 1987 Computer Conference and Exhibition, Electronic Conventions Management Inc, Los Angeles, CA.
11. Martin, James, *Design of real-time computer systems*, Prentice-Hall Inc, Englewood Cliffs, NJ.
12. Allworth, S T, *Introduction to real-time software design*, Springer-Verlag Inc, New York, NY.
13. Foster, Caxton C, *Real time programming: Neglected topics*, Addison-Wesley, Reading, MA, 1981.
14. Roberts, Steven K, *Industrial design with microcomputers*, Prentice-Hall, Englewood Cliffs, NJ, 1982.

Article Interest Quotient (Circle One)  
High 482 Medium 483 Low 484



## *“A CASE for SUN in Computer-Aided Engineering”*



It's a first! CASE Technology now offers its new Vanguard CAE Design System, a comprehensive set of electronic design applications for the system level designer—PCB and ASIC—on the SUN 3 family of engineering workstations. The system includes schematic capture, logic and fault simulation, circuit simulation, and PCB design capabilities.

The full-featured Vanguard system and the SUN 3 workstation represents one of the best values available for a high performance CAE design system. Using Ethernet TCP/IP and NFS, SUN 3 engineering workstations and personal computers can be networked together to create a completely integrated engineering environment.

CASE promotes its flexibility as a front-end CAE design tool for users

concerned with integration of existing tools and as a facility solution for those interested in a single source for all of their CAE needs.

With more than 3000 installed systems worldwide, CASE Technology has developed a solid reputation as a premier supplier of professional CAE design tools. If you haven't seen what CASE has to offer, then now is the time.

CASE Technology Inc., 2141 Landings Drive,  
Mountain View, California 94043  
Phone (415)962-1440; Telex 506513;  
FAX (415)962-1466.

# **CASE TECHNOLOGY**

# TOSHIBA. THE POWER



**AREA SALES OFFICES:** **CENTRAL AREA,** Toshiba America, Inc., (312) 945-1500; **EASTERN AREA,** Toshiba America, Inc., (617) 272-4352; **NORTHWESTERN AREA,** Toshiba America, Inc., (408) 244-4070; **SOUTHWESTERN REGION,** Toshiba America, Inc., (714) 259-0368; **SOUTH CENTRAL REGION,** Toshiba America, Inc., (214) 480-0470; **SOUTHEASTERN REGION,** Toshiba America, Inc., (404) 368-0203; **MAJOR ACCOUNT OFFICE, POUGH-KEEPSIE, NEW YORK,** Toshiba America, Inc., (914) 462-5710; **MAJOR ACCOUNT OFFICE, BOCA RATON, FLORIDA,** Toshiba America, Inc., (305) 394-3004. **REPRESENTATIVE OFFICES:** **ALABAMA,** Montgomery Marketing, Inc., (205) 830-0498; **ARIZONA,** Summit Sales, (602) 998-4850; **ARKANSAS,** MIL-REP Associates, (512) 346-6331; **CALIFORNIA** (Northern) Elrepc, Inc., (415) 962-0660; **CALIFORNIA** (L.A. & Orange County) Bager Electronics, Inc., (818) 712-0011, (714) 957-3367, (San Diego County) Eagle Technical Sales, (619) 743-6550; **COLORADO,** Straube Associates Mountain States, Inc., (303) 426-0890; **CONNECTICUT,** Datcom, Inc., (203) 288-7005; **FLORIDA,** Sales Engineering Concepts, (305) 426-4601, (305) 682-4800; **GEORGIA,** Montgomery Marketing, Inc., (404) 447-6124; **IDAHO,** Components West, (509) 922-2412; **ILLINOIS,** Carlson Electronic Sales, (312) 956-8240, R.W. Kunz, (314) 966-4977; **INDIANA,** Leslie M. DeVoe Company, (317) 842-3245; **IOWA,** C.H. Horn, (319) 393-8703; **KANSAS,** D.L.E. Electronics, (316) 744-1229; **KENTUCKY,** Leslie M. DeVoe Company, (317) 842-3245; **LOUISIANA,** MIL-REP Associates, (713) 444-2557; **MAINE,** Datcom, Inc., (617) 891-4600; **MASSACHUSETTS,** Datcom, Inc., (617) 891-4600; **MICHIGAN,** Action Components Sales, (313) 349-3940;

# IN MEMORIES.

**We are the leader in 1Mb DRAMs. In 256K static RAMs and 1Mb VSRAMs, CMOS EPROMs and 1Mb ROMs. Yet, people still think of us only as the world leader in CMOS and NMOS static RAMs.**

We are the world leader in CMOS and NMOS static RAMs. We make fast 2Kx8, 4Kx4 and 16Kx4 static RAMs — all at 25 ns! And a 1Mb VSRAM at 100 ns. We also offer 64Kx1, 8Kx8, 8Kx9 (at 35 ns) and industry standard 32Kx8 CMOS static RAMs.

But we make a lot more than static RAMs. The chart shows we have a complete line of DRAMs and EPROMs with a high density 1Mb EPROM and one-time programmables. And they are all in volume production today.

## Tradition of being first.

We were also the first to introduce the 1Mb DRAM and we're now the market leader. We were one of the first suppliers of 256K CMOS static RAMs. We were a leader with the 256K ROM and within a year of introduction, we shipped more than all other suppliers combined. And we are matching that with our 1Mb CMOS mask ROM.

So you can see that we have the capability to supply the memory products you want — when you want them.

TOSHIBA MEMORY PRODUCT SUMMARY							
PART NO.	ORG.	PROCESS	SAMPLES	PROD.	SPEED SORTS AVAILABLE (ns)		PKG OPTIONS & COMMENTS
DYNAMIC RAMS							
TMM4126AP/AT/AZ	256KX1	NMOS	YES	YES	100	120 150	P, T, Z
TMM41257AP/AT/AZ	256KX1	NMOS	YES	YES	100	120 150	P, T, Z
TMM41464AP/AT/AZ	64KX4	NMOS	YES	YES	100	120 150	P, T, Z
TC511000P/J/Z	1MbX1	CMOS	YES	YES	85	100 120	P, J, Z
TC511001P/J/Z	1MbX1	CMOS	YES	YES	85	100 120	P, J, Z
TC511002P/J/Z	1MbX1	CMOS	YES	YES	85	100 120	P, J, Z
TC514256P/J/Z	256KX4	CMOS	YES	YES	85	100 120	P, J, Z
TC514258P/J/Z	256KX4	CMOS	YES	YES	85	100 120	P, J, Z
THM81000S/L	1MbX8	CMOS	YES	YES	85	100 120	S, L
THM91000S/L	1MbX9	CMOS	YES	YES	85	100 120	S, L
STATIC RAMS							
TMM2016BP	2KX8	NMOS	YES	YES	90	100 120 150	P24, 600 mil DIP
TMM2015BP	2KX8	NMOS	YES	YES	90	100 120 150 200	P24, 300 mil DIP
TC551718CPL	2KX8	CMOS	YES	YES	150	200	P24, 6T Cell Ultra Low Power
TC551718CFL	2KX8	CMOS	YES	YES	150	200	F24, 6T Cell Ultra Low Power
TMM2064P	8KX8	NMOS	YES	YES	70	100 120 150	P28, 600 mil DIP
TMM2064AP	8KX8	NMOS	1287	03788	70	100 120	P28, 600 mil DIP
TMM2063P	8KX8	NMOS	YES	YES	70	100 120 150 200	P28, 300 mil DIP
TMM2063AP	8KX8	NMOS	1287	03788	70	100 120	P28, 300 mil DIP
TC5565APL	8KX8	CMOS	YES	YES	100	120 150	P28, 4T Cell Low Power
TC5565APL	8KX8	CMOS	YES	YES	100	120 150	F28, 4T Cell Low Power
TC5565APL	8KX8	CMOS	YES	YES	100	120 150	P28, 300 mil DIP/4T Cell
TC5564APL	8KX8	CMOS	YES	YES	150	200	P28, 6T Cell Ultra Low Power
TC5564APL	8KX8	CMOS	YES	YES	150	200	F28, 6T Cell Ultra Low Power
TC55257PL	32KX8	CMOS	YES	YES	85	100 120	P28, 4T Cell Low Power
TC55257APL	32KX8	CMOS	YES	YES	85	100 120	P28, 4T Cell Low Power
TC55257APL	32KX8	CMOS	YES	YES	85	100 120	F28, 4T Cell Low Power
TC51832PL	32KX8	CMOS	YES	YES	85	100 120	P28, Pseudo Static
TC51832SPL	32KX8	CMOS	1187	YES	85	100 120	P28, 300 mil DIP
TC51832FL	32KX8	CMOS	YES	YES	85	100 120	P28, Flat Pack
TC518128P	128KX8	CMOS	YES	0188	†	100 120	P32, Pseudo Static
TC518128P	128KX8	CMOS	YES	0188	160 190		P32, Virtually Static
HIGH SPEED STATIC RAMS							
TMM2018AP	2KX8	NMOS	YES	YES	25	35 45	P24
TMM2068AP	4KX4	NMOS	YES	YES	25	35 45	P20
TMM2088P	8KX8	NMOS	YES	YES	35	45 55	P28
TMM2089C	8KX9	NMOS	YES	YES	35	45 55	C28
TMM2089P	8KX9	NMOS	YES	YES	35	45 55	P28
TC5561P	64KX1	CMOS	YES	YES	†	* 70	P22, 4T Cell Low Power
TC5561J	64KX1	CMOS	YES	0188	†	* 70	J24, 4T Cell Low Power
TC5562P	64KX1	CMOS	YES	YES	35	45 55	P22, 4T Cell Low Power
TC5562J	64KX1	CMOS	YES	YES	35	45 55	J24, 4T Cell Low Power
TC55416P	16KX4	CMOS	YES	YES	25	35 45	P22
TC55416J	16KX4	CMOS	YES	YES	25	35 45	J24
TC55417P	16KX4	CMOS	YES	YES	25	35 45	P24, OE
TC55417J	16KX4	CMOS	YES	YES	25	35 45	J24, OE
EPROMS							
TMM2764AD~	8KX8	NMOS	YES	YES	150	200	D
TMM2764AD~	8KX8	NMOS	YES	YES	150	200	D
TMM27128AD~	16KX8	NMOS	YES	YES	150	200	D
TMM27128AD~	16KX8	NMOS	YES	YES	150	200	D
TMM27256AD~	32KX8	NMOS	YES	YES	150	200	D
TMM27256AD~	32KX8	NMOS	YES	YES	150	200	D
TC57256AD	32KX8	CMOS	YES	YES	150	200	D
TMM27512D~	64KX8	NMOS	YES	YES	200	250	D
TMM27512D~	64KX8	NMOS	YES	YES	200	250	D
TC571000D	128KX8	CMOS	YES	YES	200	250	D
TC571001D	128KX8	CMOS	YES	YES	200	250	D
ONE TIME PROGRAMMABLES							
TMM2464AP	8KX8	NMOS	YES	YES	200		PF
TMM24128AP	16KX8	NMOS	YES	YES	200		PF
TMM24256AP	32KX8	NMOS	YES	YES	200		PF
TC54256AP	32KX8	CMOS	YES	YES	200		PF
TMM24512P	64KX8	NMOS	YES	YES	250		PF
MASK ROMS							
TC53257P	32KX8	CMOS	YES	YES	200		F, P28
TC531000P	128KX8	CMOS	YES	YES	200		F, P28
TC532000P	256KX8	CMOS	YES	YES	200		P32
P = PLASTIC C = CERAMIC F = FLAT PACK D = CERDIP Y = DIE T = PLCC S = SOJ L = LEADED MODULE Z = ZIP ~ = ±10% Vcc AVAILABLE S = SOCKET MODULE * = SELECTABLE SPEED SORT AVAILABLE † = IN DEVELOPMENT							

**TOSHIBA. THE POWER IN MEMORIES.**

**TOSHIBA AMERICA, INC.**

MINNESOTA, Electric Component Sales, (612) 933-2594; MISSISSIPPI, Montgomery Marketing, Inc., (205) 830-0498; MISSOURI, D.L.E. Electronics, (316) 744-1229; MONTANA, Components West, (206) 885-5880; NEVADA, Elrepro, Inc., (415) 962-0660; NEBRASKA, D.L.E. Electronics, (316) 744-1229; NEW ENGLAND, Datcom, Inc., (617) 891-4600; NEW HAMPSHIRE, Datcom, Inc., (617) 891-4600; NEW JERSEY, Nexus Technology, (201) 947-0151; NEW MEXICO, Summit Sales, (602) 998-4850; NEW YORK, Nexus Technology, (201) 947-0151; PI-TRONICS, (315) 455-7346; NORTH CAROLINA/SOUTH CAROLINA, Montgomery Marketing, Inc., (919) 467-6319; NORTH DAKOTA/SOUTH DAKOTA, Electric Component Sales, (612) 933-2594; OHIO, Steffen & Associates, (216) 461-8333; (419) 884-2313, (513) 293-3145; OKLAHOMA, MIL-REP Associates, (214) 644-6731; OREGON, Components West, (503) 684-1671; PENNSYLVANIA, Nexus Technology, (215) 675-9600, Steffen & Associates, (214) 276-7366; RHODE ISLAND, Datcom, Inc., (617) 891-4600; TENNESSEE, Montgomery Marketing, Inc., (205) 830-0498; TEXAS, MIL-REP Associates, (512) 346-6331, (713) 444-2557, (214) 644-6731; UTAH, Straube Associates Mountain States, Inc., (801) 263-2640; VERMONT, Datcom, Inc., (617) 891-4600; WEST VIRGINIA, Steffen & Associates, (419) 884-2313; WASHINGTON, Components West, (206) 885-5880, (509) 922-2412; WISCONSIN, Carlson Electronics, (414) 476-2790, Electric Component Sales, (612) 933-2594; WYOMING, Straube Associates Mountain States, Inc., (303) 426-0890; CANADA, BRITISH COLUMBIA, Components West, (206) 885-5880; ONTARIO, Electro Source, Inc., (416) 675-4490, (613) 726-1452.

© 1987 Toshiba America, Inc.

# MAKE REAL-TIME FLY.



Now you can unleash all the raw power of the 80386 for real-time applications. All you need is our new iRMK™ real-time multi-processor kernel. It's the lean, clean core of a full-featured operating system.

Its blazing speed lets you keep up with the most demanding applications. Average interrupt response time is less than 10 microseconds. That's incredibly fast.

But more important is the iRMK

kernel's feature set. Which includes interrupt management, time management, mailboxes, semaphores, multi-tasking, and preemptive, priority-based scheduling.

And if you want more power, the iRMK kernel lets you use more processors. It's the only kernel that delivers multiprocessing support for the MULTI-BUS® II Message Passing Co-processor.

Besides running fast, your application will also run right. Because we offer more reliability features than any other real-time kernel. Like user-defined objects. And priority adjusting semaphores (regions) to avoid deadlock.

And if your application requires features beyond what a kernel can deliver, we offer the iRMX® 286. A complete real-time operating system that runs on the 80386 without modification.

In addition to basic kernel functions, it has reprogrammability, a human interface and on-target development.

iRMX 286 and the iRMK kernel are the latest developments in an operating system family we've been refining since real-time began for micro-processors. Currently, there are over half a million CPUs running iRMX, making it the most popular real-time O/S family in the world.

You'll also be glad to know that iRMX

operating systems are solidly in touch with the rest of the real-time world. Our OpenNET™ Network connects it to VAX/VMS and even PC DOS compatibles.

REAL TIME COMPARISON			
	Interrupt Latency	Development Host	Regions
iRMK	10 µsec.	PC-DOS	yes
iRMX 286	13 µsec.	self hosted	yes
VAXELN	33 µsec.	VAX/VMS	no

What's more, iRMK and iRMX are easy to get started with. Because they run on our industry standard family of open system MULTIBUS hardware. Including our new 20 MHz 80386

MULTIBUS I and II boards. We even offer complete systems for OEMs like our new 80386-based System 320.

And we top it all off with re-entrant compilers, debuggers, utilities, customer training and consulting.

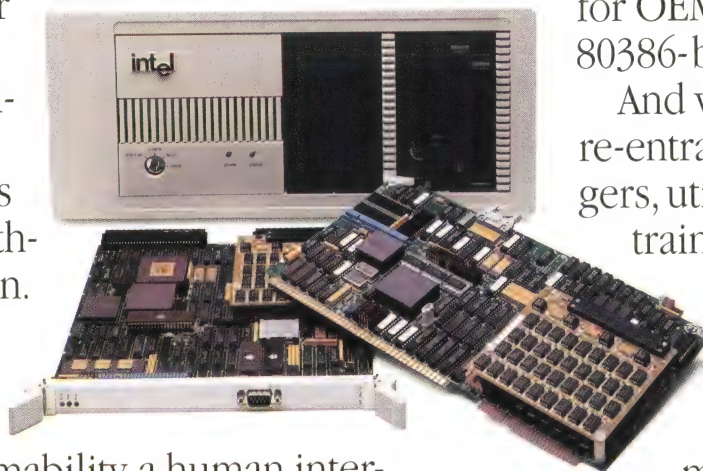
All designed to make your design task easier and faster.

So why waste any more time? For a real-

time response from Intel, call our toll-free number: (800) 548-4725, and ask for Literature Department W-392.

We'll mail a complete information packet within one working day.

And you'll see how quickly time flies when Intel is on your side.



MULTIBUS and iRMX are registered trademarks and OpenNET and iRMK are trademarks of Intel Corporation. ©1987 Intel Corporation

Visit us at Buscon West, Anaheim, CA, Feb. 23-25, Booth 64

# PROVEN

## 500 TO 1600 WATT POWER SUPPLIES

### NEW 1600W MULTI's

The industry's newest, smallest 1600W Multi output package. ACDC's JFM features unlimited flexibility of output voltage & current combinations.

Any combination you choose will be delivered in 2 weeks.

### PROVEN 1600W MULTI's

A new product that's proven?

YES—when it's based on ACDC's design used for the industry's most reliable "slot" supply.

YES—when it passes ACDC's rigorous, unforgiving quality & reliability test program.

### PROVEN 1000W & 800W MULTI's

Proven by our customers. Proven over a broad variety of applications. Don't compromise on output voltage. ACDC's REV 1000/800 Series has the output combination your design requires.

And you can have it in 2 weeks.

#### MODEL SELECTION CHART

WATTS	SINGLE	MULTI UP TO 5 OUTPUTS
1600		
1500		
1000		
800		
750		
500		

### PROVEN. 1500W, 1000W, 750W SINGLES

High performance, competitive pricing and 2 week delivery have made this the most popular proven "slot" supply in the industry.

Unequivocally.

### PROVEN FEATURES

- IEEE 587 input surge protection
- Current mode control
- Single wire paralleling
- On-board EMI filter (FCC Docket 20780, Class A and VDE 0871, Class A)
- Largest offering of standard options
- Active preload
- Dynamic soft-start
- International safety certifications

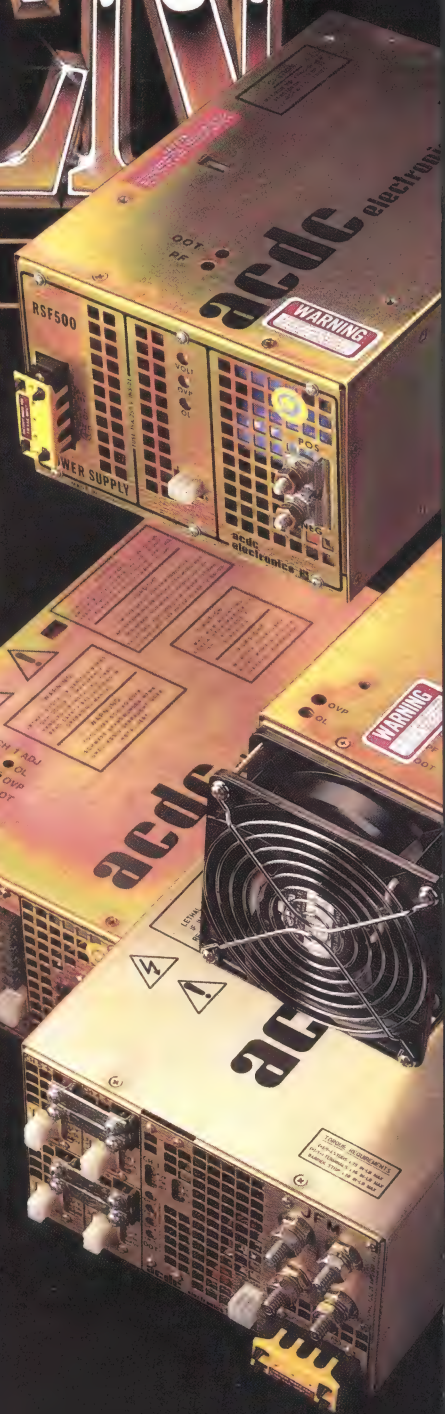
### PROVEN

ACDC electronics designs & builds quality, highly reliable power supplies. This has been PROVEN for over 30 years. And continues to be PROVEN every day.

## NEW

Now there are NEW solutions to your 500-1600W power supply requirements.

PROVEN solutions. Only from ACDC electronics. Want proof? Call for a DEMO today. (619) 439-4200.



401 Jones Road, Oceanside, CA 92054  
TEL: 619/757-1880, TLX: 350227, FAX: 619/439-424

**acdc**  
electronics

1600w 1500w 1000w 800w 750w 500w 400w 300w 220w 175w 135w 70w 40w 15w

ACDC's POWER OFFERING

CIRCLE NO 88

# DC/DC converters adapt to the needs of low-power circuits

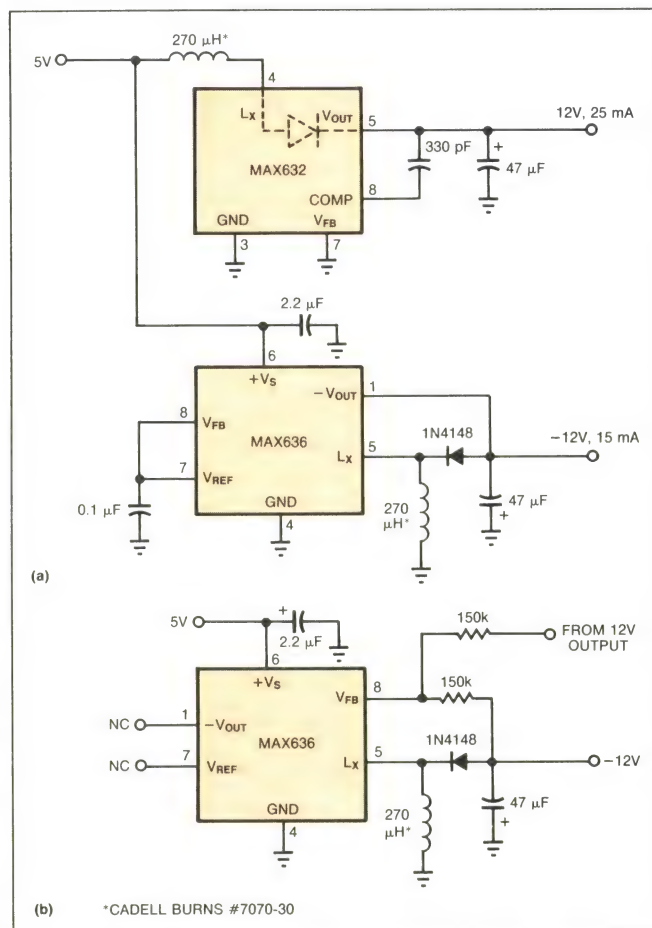
*High cost, quiescent current, and circuit complexity have often restricted switching power supplies to high-power applications, for which the switchers' high efficiency, wide input range, and reduced size and weight offset their drawbacks. Now, however, you can employ switchers in low- and medium-power applications as well.*

Len Sherman, *Maxim Integrated Products*

Designers of dc/dc-conversion products are now addressing the special requirements of low- and medium-power applications. As a result, you can apply switching techniques' advantages in battery-powered portable equipment, telemetry devices, and consumer products.

A key requirement for designers of battery-powered products is that they minimize the number of cells used in the product. Substituting, for example, two large cells for a stack of six or seven smaller ones yields not only reductions in size and weight but also increased reliability and energy density. An efficient, low-power step-up voltage converter used in conjunction with a few high-capacity, low-voltage cells makes such a trade feasible, especially in an application where a stack of expensive rechargeable batteries would be the alternative.

The circuits shown in Figs 1 through 7 are all



**Fig 1—You can tailor this  $\pm 12V$  supply to provide either independently regulated outputs (a) or a tracking negative output (b). The inductors don't exact too great a size penalty: Each measures only 0.6 in. long by 0.26 in. in diameter.**

*The flyback configuration keeps circuitry compact, and it adapts not only to voltage boosting but to buck and buck/boost configurations as well.*

flyback-type switching dc/dc converters (the same type that generates 10- to 20-kV supplies for television, video display terminals, and oscilloscopes) that operate at 50 kHz (see **box**, "Flyback converters' internal operation"). The flyback configuration keeps the circuitry compact, and its versatility allows it to accomplish more than simple voltage boosting.

### Derive $\pm 12\text{V}$ from digital system's supply

Often, a digital system powered by a 5V supply includes a few analog functions that require  $\pm 12\text{V}$ . The circuit shown in **Fig 1** uses two dedicated 8-pin converters—the MAX632 and MAX636—to derive 25 mA at 12V and 15 mA at  $-12\text{V}$  from a 5V logic supply. You can configure the circuit for independently regulated outputs (**Fig 1a**) or for tracking regulation (**b**).

The positive converter's efficiency is 85%; the inverter's is 75%. You can improve these efficiency figures slightly by using Schottky diodes rather than the MAX632's internal diode and the 1N4148 signal diode connected to pin 5 of the MAX636. If you opt to use a Schottky diode with the MAX632, connect it in parallel with the chip's internal diode (that is, between pins 4 and 5).

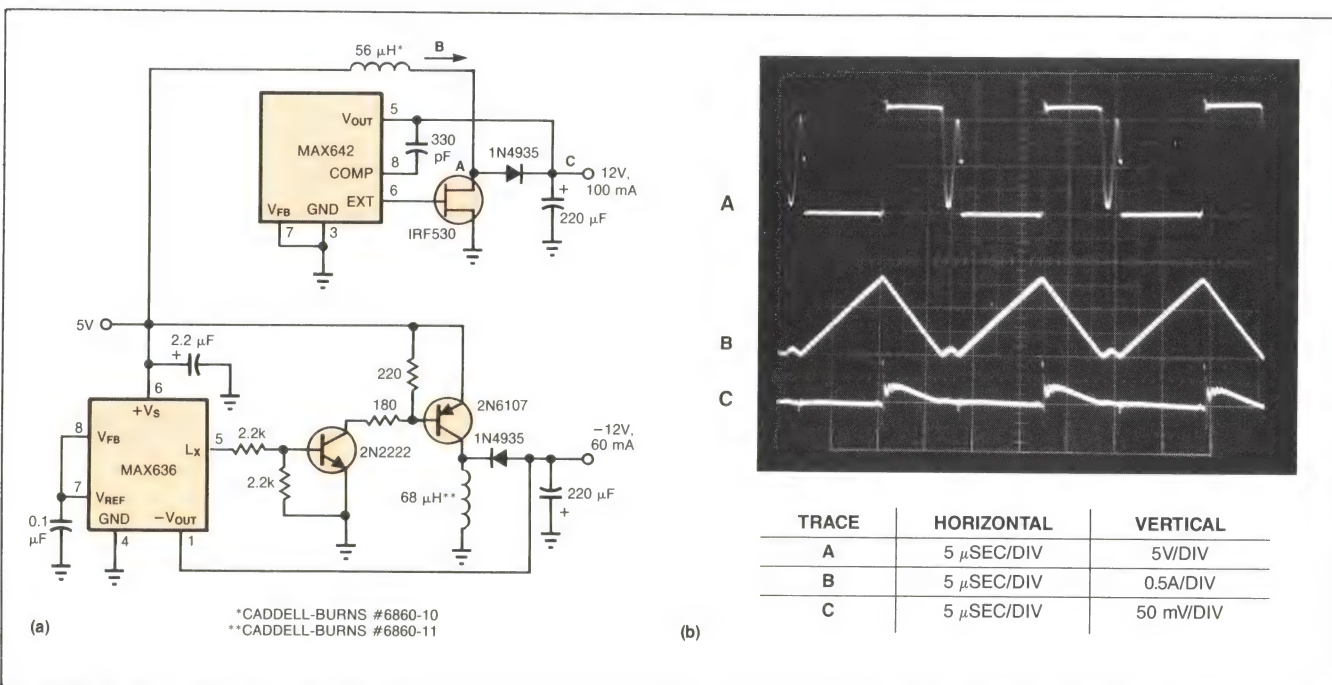
With several popular types of high-current rectifier diodes, such as ones in the 1N4000 Series, efficiency

and overall performance are poor for high-frequency (greater than 10 kHz) dc/dc conversion. Many of these diodes were designed to pass high current only at 120 Hz; therefore, they waste energy at 50-kHz operating frequencies. In addition, these slow rectifiers might also allow the inductor's discharge voltage to reach excessive levels before the rectifier turns on and directs current to the load.

Small-signal diodes, such as the 1N4148, are fast enough and work well in applications that require less than 50 mA. High-speed rectifiers, such as the 1N4935, are suitable in applications that require as much as 1A. Schottky diodes provide the best performance with respect to speed and forward voltage drop, and they can significantly improve efficiency in low-voltage, high-current applications. However, you'll have to decide on the basis of your individual application whether their higher cost and relatively low reverse breakdown voltage eliminate the Schottky diodes from consideration.

### External MOSFET increases power

If your application requires higher power than **Fig 1**'s circuit provides (if, for instance, you need the power for a data-acquisition board or a high-level industrial controller), then you can modify the circuit by adding an



**Fig 2—With the addition of a few external components (a), the circuit of Fig 1 can supply currents of 100 mA at 12V and 60 mA at  $-12\text{V}$ . Traces A, B, and C (b) represent the switch voltage, inductor current, and output ripple for the 12V supply.**

external power MOSFET, as shown in **Fig 2a**, and obtain 100 mA at 12V and 60 mA at -12V. The power MOSFET drops the 12V converter's efficiency to 80%, but driving the power MOSFET doesn't require any additional parts.

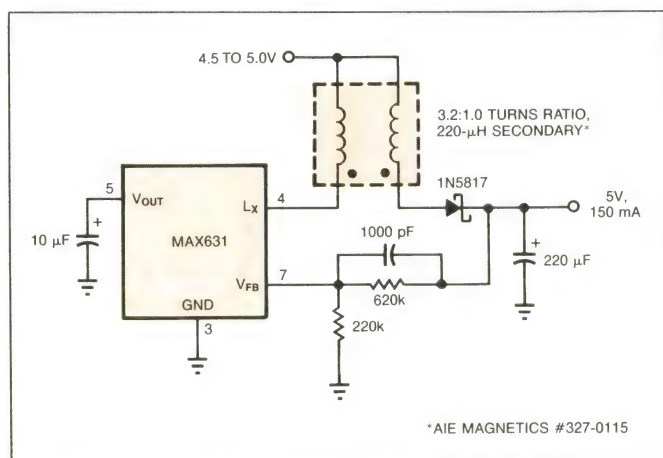
The scope photo (**Fig 2b**) shows some of the key waveforms in the step-up circuit. Trace A is the voltage waveform at the drain of the IRF530 MOSFET (under full load), trace B is the inductor current, and trace C is the ripple voltage at the 12V output. The ringing found on trace A near the end of each discharge cycle is normal and is due to the inductor's interaction with stray capacitance when the inductor current decays to nearly zero. As you can see from trace C, this ringing has no effect on the output waveform.

### Compensate for IR drops

Not only might you need to derive  $\pm 12\text{V}$  from a 5V supply, you might also need to derive a regulated 5V level from a nominal 5V supply that suffers from an unacceptable voltage drop because of IR effects in long power-distribution cables. You can efficiently boost the voltage back to a regulated 5V by using the circuit shown in **Fig 3**.

That circuit operates at input voltages as low as 4.5V. The transformer's 3.2:1 turns ratio allows the circuit to supply more than the MAX631's usual output current without requiring external power transistors. This circuit provides as much as 150 mA of output current at 5V. You can wind the transformer on a 14 $\times$ 8-mm pot core, or you can obtain the transformer by ordering the standard part number listed in the schematic.

When the MAX631's  $L_X$  switch turns off at each half



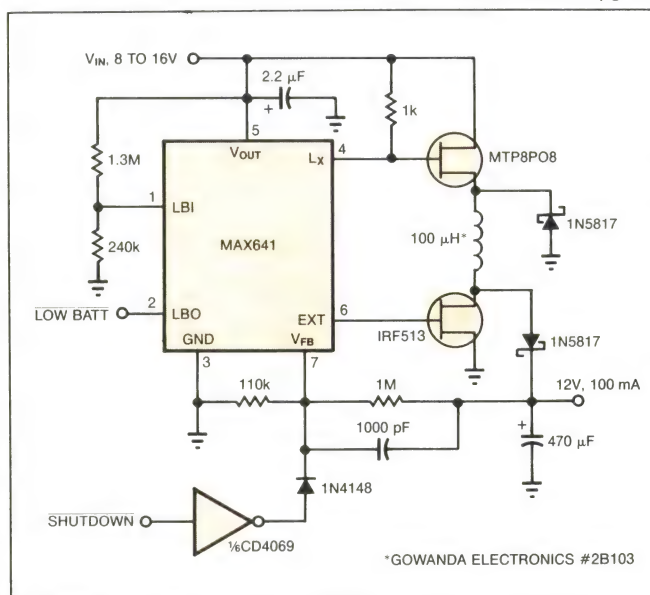
**Fig 3**—This simple circuit boosts a supply voltage that might have sagged substantially because of IR drops in long cables.

cycle of its 50-kHz clock, the reflected voltage in the transformer's primary generates a 9V supply voltage for the MAX631 at the  $V_{OUT}$  pin. Operating the MAX631 at 9V rather than at the 4.5V provided at the input increases the gate-source voltage of the internal MOSFET, consequently reducing the MOSFET's on-resistance. This circuit requires the external feedback resistors at  $V_{FB}$  because, unlike the previous circuits, this circuit doesn't allow you to use  $V_{OUT}$  as the feedback input for the regulator.

### Derive 12V from 8 to 15V input

The simple boost converters of the previous examples are inadequate for some battery-powered applications. For example, the unregulated output of a 12V sealed lead-acid battery varies from worst-case peaks of 15V down to as little as 8V when it is deeply discharged. Therefore, you can't derive a regulated 12V output from a 12V lead-acid battery by using a simple boost converter, such as one of those illustrated in **Figs 1** and **2**, because a boost converter can't accept an input voltage that is greater than its output voltage. Conversely, a buck converter can't accept an input voltage that's less than its output; therefore, a simple buck converter won't work either. A buck/boost converter, as the name implies, is a combination of buck and boost circuitry that successfully addresses the challenge of

Text continued on pg 150



**Fig 4**—A buck/boost converter can accommodate wide input-voltage swings, such as the 8 to 15V swing typical of a 12V sealed lead-acid battery. The LOW BATT output indicates when input voltage drops below 8V. Pulling SHUTDOWN low turns off the circuit.

## Flyback converters' internal operation

In a flyback converter, voltage applied to an inductor or transformer primary via a switch causes inductor current to rise for a fixed period of time. When the voltage is switched off, the magnetic field stored in the transformer collapses, causing the secondary to supply current to the load. With the MAX640 and MAX630 Series devices, this switching occurs at 50 kHz. You can use these devices to step up the voltage, step it down, or invert it just by changing the configuration of the switch (transistor), coil, and steering diode.

**Fig A** illustrates the MAX641's internal operation. When the output voltage drops below the preset (or externally set) value, the error comparator switches high and connects the internal oscillator to the  $L_X$  and EXT outputs. EXT is typically connected to the gate of an external n-channel power MOSFET (although the external MOSFET isn't necessary for most of the low-power circuits discussed in

the accompanying article). When EXT is activated, the MOSFET turns on and off at the oscillator frequency.

When EXT is high, the MOSFET switches on, and the inductor current increases linearly, storing energy in the coil. When EXT switches the MOSFET off, the coil's magnetic field collapses, and the voltage across the inductor changes polarity. The voltage at the catch diode's anode then rises until the diode is forward-biased, delivering power to the output. As the output voltage reaches the desired level, the error comparator inhibits EXT until the load discharges the output capacitor to a point at which the error comparator connects the oscillator to the  $L_X$ , and EXT generates output once again.

The MAX641 doesn't have a  $V_{IN}$  pin. Input power to start the dc/dc converter is supplied via the external inductor (and external diode, if used), to the  $V_{OUT}$  pin. If you use an external catch

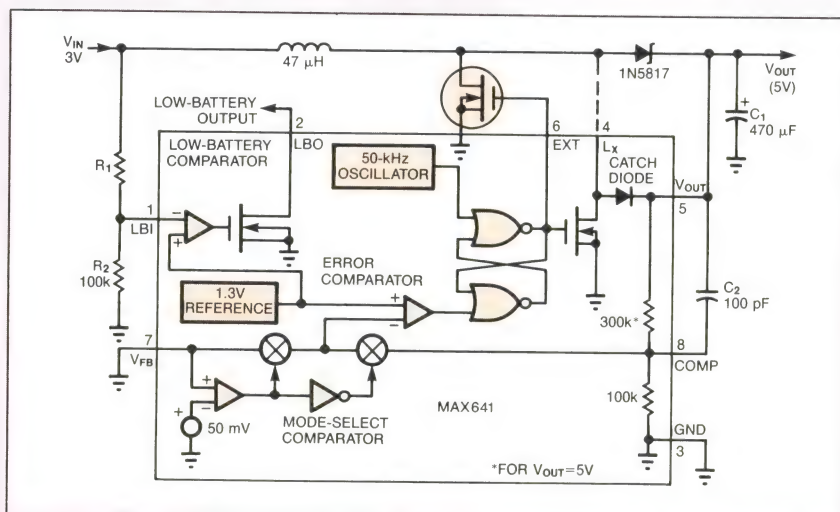
diode, connect its cathode to  $V_{OUT}$ . Once the converter is started, it's powered from its own output voltage. This bootstrap design ensures that the external MOSFET has the maximum gate drive and, consequently, the minimum  $R_{ON}$ .

One external component that you must select is the inductor. Although the inductance of many types of coils, such as RF chokes and air-core inductors, frequently falls in the appropriate range for dc/dc converters (50 to 500  $\mu\text{H}$ ), these inductors typically saturate at only a few milliamps and therefore are not a good choice for your dc/dc-converter design.

A saturated inductor ceases to behave as an inductor. It can no longer store energy in its magnetic field, so the mechanism that normally limits the inductor current no longer operates; all that limits the current is the series resistance. This resistance is quite low; consequently, the current can rise to an excessive, and possibly destructive, level.

The scope photo in **Fig B** shows the switch voltage (trace A) and inductor-current waveforms (trace B) for an inductor that's well on its way to saturation. Compare these waveforms with the normal performance illustrated in **Fig 2b** on pg 146. The A and B waveforms in both photos are of the same A and B nodes of the 12V boost circuit in **Fig 2a**. **Fig B** reflects the effects of using an inductor with an inadequate current rating in **Fig 2a's** circuit.

When you look at **Fig B**, you'll see that, in the middle of the



**Fig A**—This block diagram illustrates the MAX641's operation. For many low-power applications, the external MOSFET and Schottky diode are unnecessary.

charge cycle, above the 0.5A level, the current waveform's slope increases markedly, indicating the onset of saturation. At this point, the effective inductance of the coil decreases because the current through the inductor has risen to the saturation level. The rising edge of the switch-voltage waveform is much slower in **Fig B** than in **Fig 2b** because the inadequately rated inductor takes several microseconds to come out of saturation.

An inductor doesn't saturate as long as its operating current is less than its rated maximum current. At first glance, it would seem easy enough to specify the maximum current rating for your inductor, but what you have to watch out for in your dc/dc designs is that the peak inductor current is often four to six times the converter's average current output. In the case of flyback converters, this peak current flows not just under peak load conditions, but each

time the current switch turns on. For this reason, you must give careful consideration to the current rating of your converter circuit's inductor.

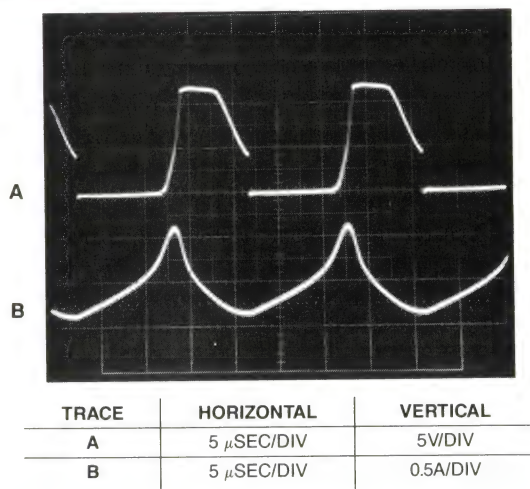
Besides the care required in the selection of inductors, another often-overlooked area of concern in dc/dc-converter design is that encompassed by grounding, shielding, and bypassing. The quality of ground connections is key to the performance of dc/dc converters. Because the peak current in an inductor or switch (transistor) can reach several amps, you must provide these points with very-low-impedance paths to the supply common. For example, in the inverting circuit of **Fig 2a**, the coil current typically exceeds 1A. For best results, use separate paths to ground for the high-current paths so that they are separated from the chip's power and feedback connections. If you don't have the option of separate traces, then use as heavy a sin-

gle trace as you possibly can to carry the high current back to the supply.

Loop instabilities, caused by interactive ground connections or stray capacitive pickup, can also severely limit the performance of an otherwise sound dc/dc-converter design. Some of the symptoms of these problems are high ripple voltages at the output, efficiency that's lower than expected, and "motorboating," or low-frequency oscillation.

Motorboating occurs when the control loop of the dc/dc converter produces pulses in periodic clusters of 10 to 20 pulses rather than at more or less random intervals. Motorboating can be caused by one or more of the following phenomena: stray pickup at the feedback node, unwanted feedback to the reference, and feedback via the ground or power-input pin.

If the cause is stray pickup at the feedback node, add a lead compensation capacitor (100 to 1000 pF) from the feedback terminal or COMP pin to the circuit output or reduce the size of your connections at the feedback input in order to reduce stray capacitance to ground. If unwanted feedback to the reference is the culprit, bypass the reference and power-input pins to ground (using 0.1 to 1.0  $\mu$ F). If your circuit is suffering from feedback via the ground or power-supply input (1.0 to 10.0  $\mu$ F). You should also separate high-ground-current connections from the reference, feedback, chip-ground, and chip-power connections.



**Fig B**—The marked increase in the current waveform's slope (trace B) illustrates the onset of saturation for an inductor with an inadequate current rating. Trace A represents switch voltage.

*You must sometimes develop 5V from a nominal 5V input that has sagged because of IR drops in long power-distribution lines.*

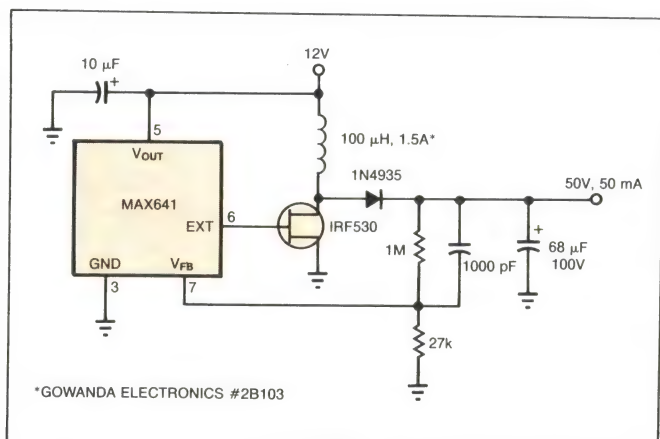
the wide input-voltage swing associated with the sealed lead-acid battery.

The circuit of **Fig 4** is a buck/boost converter that provides 100 mA at 12V and accepts 8 to 16V inputs. Both ends of the circuit's inductor are switched by separate power MOSFETs, which the MAX641 drives directly via its  $L_X$  and  $EXT$  outputs. These outputs operate out of phase, so the p- and n-channel FETs turn on at the same time. When both the n- and p-channel FETs turn off, the two Schottky diodes steer the coil's discharge current to the 12V output. A slight drawback of this circuit is that the converter's efficiency is less than that of a pure buck or boost converter, because the two MOSFETs and two diodes increase losses in the charge and discharge current paths. Nevertheless, the circuit still delivers 100 mA at a respectable 70% efficiency figure.

An additional benefit of this type of circuit is that you can control its operation with a TTL-level signal. Overriding the  $V_{FB}$  input with a high-level TTL signal (such as the diode-coupled inverter output in **Fig 4**) fools the MAX641's internal feedback circuitry into thinking that the output is too high, so the chip turns off both MOSFETs. The circuit's idle current is around 400  $\mu$ A.

#### Obtain 50V from a 12V supply

If you need to generate voltages higher than the 5 and 12V levels of the circuits shown in **Figs 1** through **4**, consider a configuration such as the one shown in **Fig 5**. It provides a 50V output from a 12V input and is simpler than **Fig 4**'s circuit: Because the output is higher than the input, a simple boost configuration suffices.

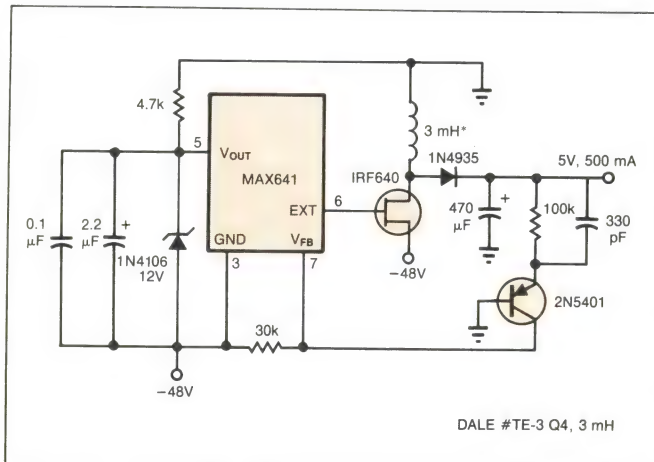


**Fig 5—Only the power MOSFET, catch diode, and output-filter capacitor need to withstand high voltages in this 50V supply circuit.**

The circuit uses an IRF530 n-channel MOSFET in conjunction with a MAX641 dc/dc controller. In this circuit, the 50V output is not connected directly back to the  $V_{OUT}$  pin because that pin has a maximum voltage rating of 18V. The circuit uses an external resistive divider network to provide feedback to the  $V_{FB}$  input. The  $V_{OUT}$  pin obtains power for the MAX641 directly from the 12V supply. The only components that must withstand high voltages are the MOSFET, the steering diode, and the output filter capacitor: They're rated at 100V, 200V, and 100V, respectively.

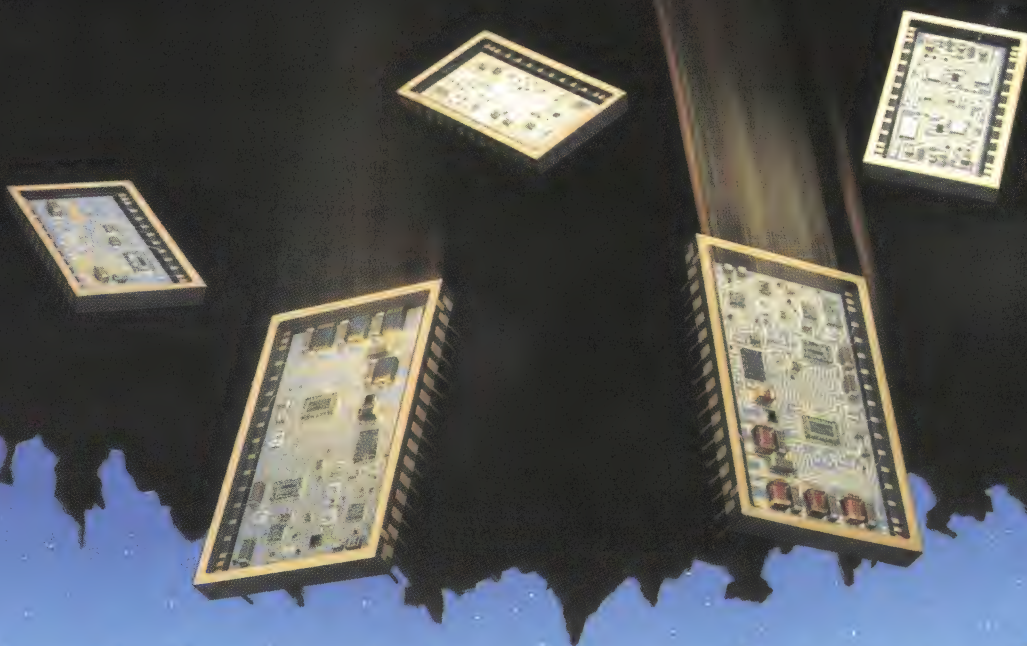
A different twist to high-voltage dc/dc conversion is the requirement to power low-voltage logic circuitry from a high-voltage source—for instance, the telephone system's -48V battery voltage. The circuit of **Fig 6** uses a basic boost configuration to convert -48V to 5V. A small-signal, high-voltage pnp transistor shifts the feedback signal from the 5V output to the MAX641, whose ground terminal (pin 3) is tied to the -48V input. The output, at 5V with respect to ground, forces about 43  $\mu$ A through the 100-k $\Omega$  sense resistor and the emitter of the 2N5401. This current is sent through the 30-k $\Omega$  input resistor at  $V_{FB}$ , placing this pin 1.3V above the ground pin (or at -46.7V). Because the internal reference of the MAX641 is a 1.3V bandgap reference, the 1.3V bias level at the feedback input closes the feedback loop.

This biasing scheme allows the  $EXT$  output to directly drive the n-channel MOSFET, switching the inductor to the -48V input without level shifting of the MOSFET's drive signal. The 330-pF capacitor provides feedforward compensation, which stabilizes the regula-



**Fig 6—Telecomm applications** often require you to develop your logic-level supply from -48V. Suitable for such applications, this circuit delivers 5V at 500 mA.

# SUB-MICROSECOND A/D CONVERTERS



## Break through to new performance levels

DATEL's broad range of High Speed A/D converters give you the greatest choice available today from a single source. This combination of products coupled with DATEL's commitment to bringing you the fastest most precise and reliable A/D converters, will expand your design capability and enhance your system performance levels.

Speed up your designs with DATEL converters today.

Call or write for information on all DATEL data conversion products including complementary Track and Holds.

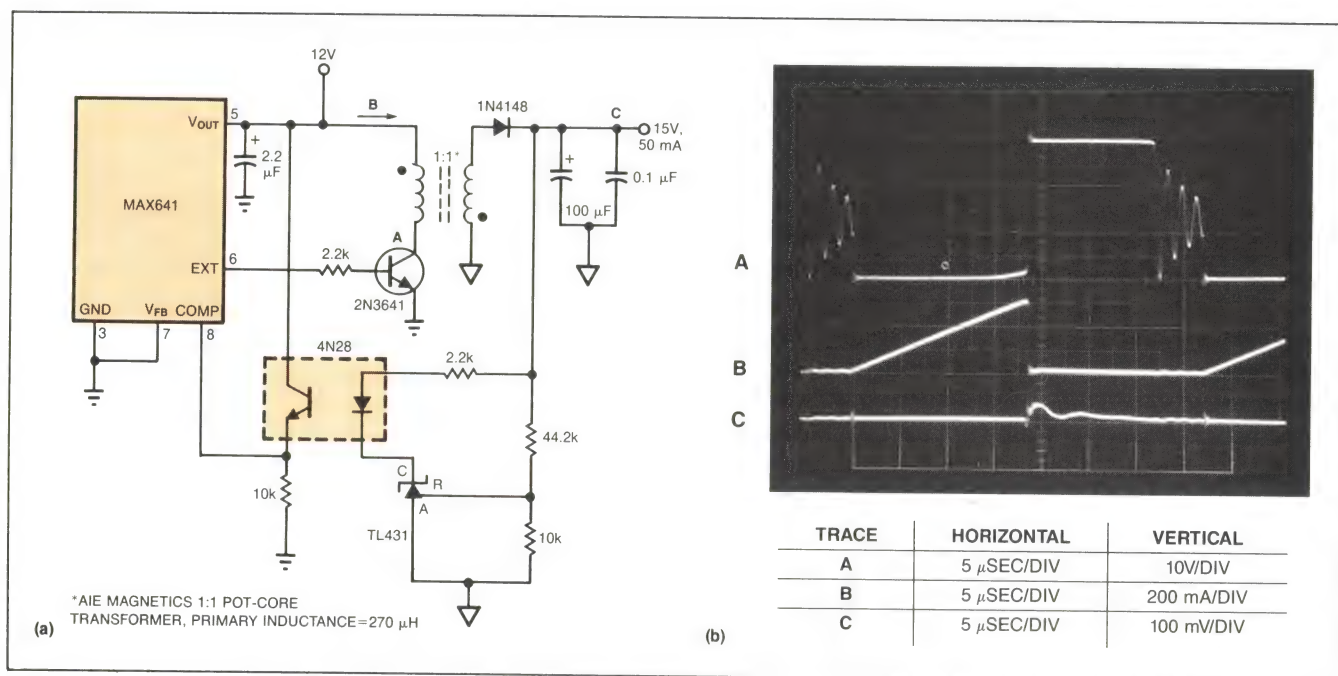
MODEL NUMBER	BITS OF RESOLUTION	CONVERSION TIME	THROUGHPUT (INCLUDING TRACK & HOLD AMPLIFIER)
ADC-500/-505/-508 ADC-B500/-B505 ADS-105/-106 ADS-21/-22	12	500-800 nSec	1.25-1.1 MHz 750 KHz 1.3/1.0 MHz
ADC-510/-515 ADS-115/-116 ADC-310	10	425 nSec 50 nSec	1.00 MHz
ADC-5101 ADC-815 ADC-303 ADC-304	8	900 nSec 700 nSec 10 nSec 50 nSec	
ADC-207	7	30 nSec	



LEADERS IN DATA CONVERSION TECHNOLOGY  
Datel, Inc., 11 Cabot Boulevard, Mansfield, MA 02048 (617) 339-3000

CIRCLE NO 42

*A buck/boost converter can deal with the wide input-voltage swings associated with sealed lead-acid batteries.*



**Fig 7—**This circuit (a) provides 50 mA at 15V with an isolation rating of 500V—a function of the transformer and opto-isolator. In the scope photo (b), traces A, B, and C represent the switch voltage, primary current, and output-voltage ripple.

tor's control loop and improves the regulator's transient-load response.

### Generating an isolated supply

In large analog systems and in industrial-control systems, you must often provide power that is electrically isolated from the main system's power source. This isolation is necessary to prevent ground loops, to protect measurement hardware from dangerous voltages, and to reject common-mode signals. The circuit in Fig 7a generates a regulated 15V, 50-mA output that is fully isolated from the 12V input supply. The circuit's output power is supplied by a 14 $\times$ 8-mm pot-core transformer, and the feedback signal returns to the unisolated side of the circuit via an opto-isolator.

Although the peak primary current of the transformer is within the ratings of the MAX641 converter IC's internal switch, you must use an external transistor to drive the transformer. The reason you need this external transistor is that when the transistor turns off, the 15V secondary voltage is reflected to the primary, placing 30V across the transistor. This 30V exceeds the MAX641's 18V rating. The transformer primary's voltage, current, and ripple voltage are illustrated in traces A, B, and C, respectively, of the Fig 7b scope photo.

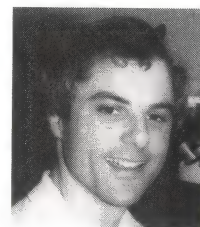
To transmit the feedback signal across the isolation barrier, the 15V output is divided and compared with

the 2.75V reference of a TL431 shunt regulator. When the voltage at the TL431's reference input exceeds 2.75V, the TL431 draws current through the opto-isolator's photodiode. The opto-isolator's transistor then pulls the COMP input of the MAX641 high, turning off the EXT output. The COMP input connects to the MAX641's internal voltage divider, and thus the opto-isolator's transistor can control the MAX641. The components specified in Fig 7a provide an isolation rating of 500V.

**EDN**

### Author's biography

Leonard H Sherman is a senior member of the technical staff at Maxim Integrated Products in Sunnyvale, CA. Leonard received his BSEE from MIT, and he has one patent to his credit. Leonard enjoys playing volleyball and collecting old hi-fi equipment in his spare time.



Article Interest Quotient (Circle One)  
High 488 Medium 489 Low 490

# ANNOUNCING THE $\mu$ CARDS<sup>TM</sup> SYSTEM... SATISFACTION GUARANTEED OR YOUR MONEY BACK

**Workstation Power For  
PCB Design At A  $\mu$ Price. From  
The SCICARDS<sup>®</sup> People.**

We're inviting you to try the  $\mu$ CARDS System. See if you don't agree that it's the fastest, easiest-to-use and most affordable major-function PCB design system in a workstation environment.

It's a cinch to use. The easy question-and-answer format requires no special training. The  $\mu$ CARDS System can handle up to 600 components and up to 20 board layers with swift, sure component moving, swapping and alignment in rows or columns and full rat's nest display. The  $\mu$ CARDS System router set whips through the design automatically and interactively with speed and accuracy; you choose the router best suited to your needs. **And you can't make a mistake.** The system provides dynamic online checking of clearances, trace widths and connectivity, assuring the integrity of all mechanical and electrical design rules.

Try the  $\mu$ CARDS System for 60 days. If after that time you don't find it to be the PCB design system that redefines price/performance standards and ease of use, we'll refund your money. We're that confident.

The  $\mu$ CARDS System at a  $\mu$ price. From the engineering that brought you the SCICARDS System. Now available on the VAXstation 2000.

For more information, write or give us a call. We'll give you a demonstration.

7796 Victor Mendon Road  
P.O. Box H  
Fishers, NY 14453  
1-800-4 HARRIS Ext. 4315  
1-800-344-2444 (Canada)



SCICARDS and  $\mu$ CARDS are trademarks of Scientific Calculations, Inc.

VAXstation 2000 and **digital** are registered trademarks of Digital Equipment Corp.

**CIRCLE NO 41**

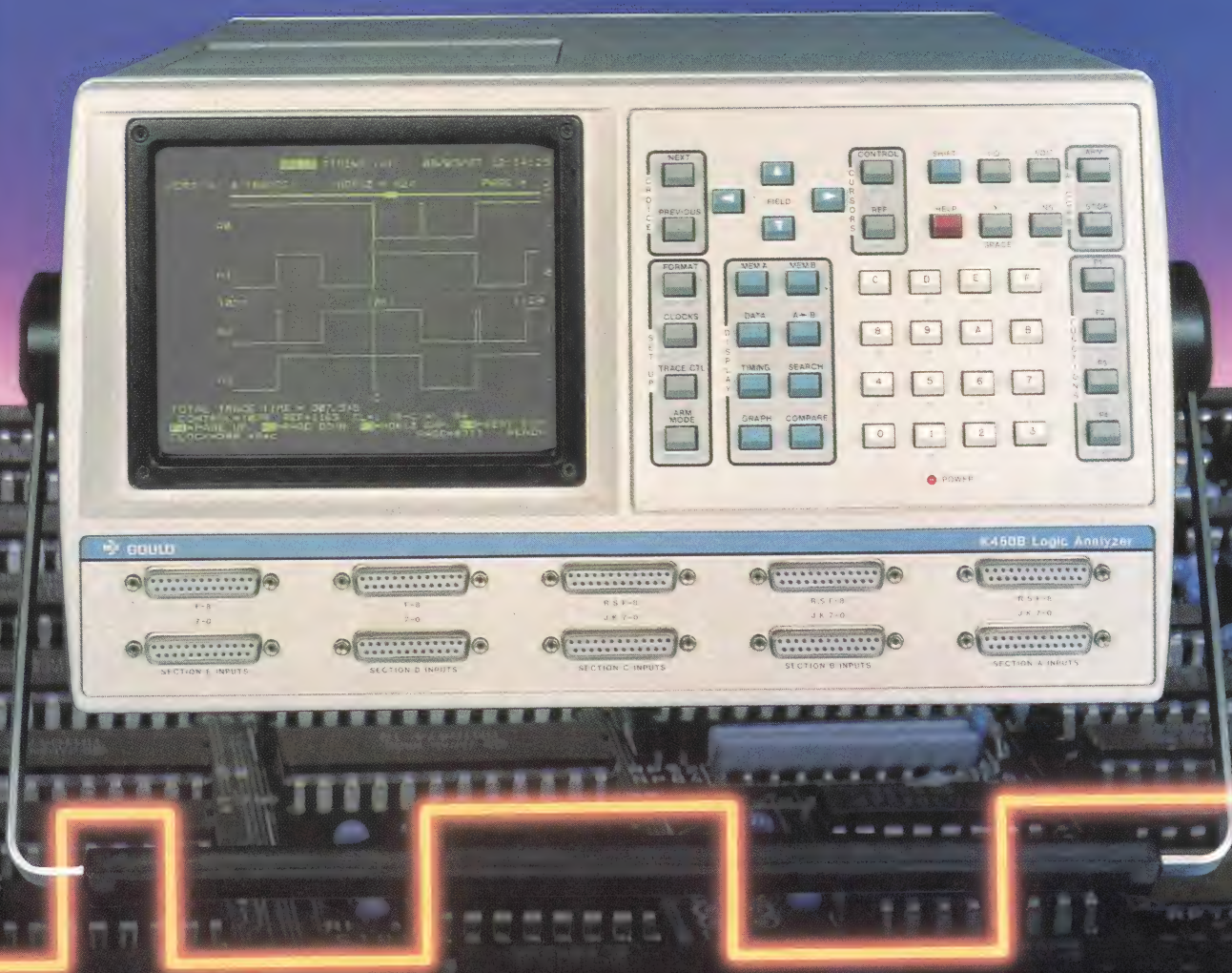




# Team Performance

**Gould 4070 Digital Oscilloscope**  
400 MS/s (sampling rate)

**Gould K450B Logic Analyzer**  
80Ch. @ 100 MHz/40Ch @ 200MHz



### Start solving your design problems today!

Gould offers two powerful tools to help the digital design engineer track down and eliminate intermittent failures. Used separately or teamed together with sophisticated triggering, they provide the power to resolve design problems.

The K450B Logic Analyzer, with 80 channels at 100MHz or 40 channels at 200MHz, gives you an overview of the whole system so that individual glitches or timing errors can be located.

Using the 4070 Digital Storage Oscilloscope, with 2 or 4 channels at 400 Megasamples per second, you can capture the analog details of the waveform and find noise transients or race conditions which can be the source of the failure.

Put Gould on your design team with our special combination offer on scopes and analyzers. Call **1-800-GOULD-10** or write to Gould Inc., Test & Measurement Group, 19050 Pruneridge Ave., Cupertino, CA 95014.

#### 4070 DSO

2 or 4 channels @ 400MS/s (400 Megasamples/sec.)
2.5ns resolution on transient signals
Auto Setup™
Trigger delay by time/events
Built-in 4 color screen plotter

#### K450B LA

80 channels all @ 100MHz/ 40 channels @ 200MHz
5ns glitch capture on all channels
Auto Setup™
16 levels of Trace Control™
Built-in disk drive



**GOULD**  
Electronics



# Hughes' Connector Line: When You Care Enough to Spec the Very Best.

These hi-rel, hi-density connectors serve the military everywhere—eloquent testimony to their versatility, reliability and exclusive features.

- Highest contact density, with 110 contacts to the square inch.
- Super-sealing, with seals on the contacts in some environmental types.
- Positive polarization with our exclusive Polar-Hex center jackscrew coupling.
- MIL-C-28840 and MIL-C-55302 versions that incorporate superior design features and qualify to spec limits.

- And our MIL-C-28876 fiber optic connector, the only multi-channel type to meet mil spec.

For more information about our standard line, phone Bob Torres at 714-660-5829. In England, Hugh McNally at 932-47262.

**HUGHES**  
AIRCRAFT COMPANY

CONNECTING DEVICES DIVISION  
Industrial Electronics Group

# Proper glitch capture requires knowledge of logic-analyzer limits

---

*Using a logic analyzer to locate the source of intermittent malfunctions in digital systems can prove to be extremely frustrating. If you understand your analyzer's capabilities and limitations, though, you raise the odds of having the instrument furnish the information you need.*

---

Wolfgang Schweitzer, *Kontron Messtechnik*

Logic analyzers are useful tools for tracking down the cause of intermittent malfunctions in digital systems. But because logic analyzers are sampled-data systems—that is, they acquire information only at discrete points in time—the information they yield can be misleading if more than one logic transition occurs between consecutive sample times.

Analyzer manufacturers have devised glitch-capture circuits that allow the instruments to indicate such transitions. Glitch capture is not infallible, however, and you should not assume that its use guarantees that you will find the transient pulse you are looking for. Moreover, logic analyzers vary in speed and in the way they capture, store, and present glitch information; some logic analyzers, in particular the very fastest, do not include special glitch-capture circuits. Therefore, if you want to use an analyzer to best advantage, you must understand how it operates, and, sometimes, how

to employ additional instruments, such as an oscilloscope, in conjunction with it.

## **Use internal clock for best resolution**

Most modern logic analyzers can operate either as logic-state analyzers or as timing analyzers. When a logic analyzer performs timing analysis, it can use an internal sample clock and thus operate asynchronously from the system under test (SUT). An analyzer can also use a clock derived from the SUT and thereby operate synchronously with that system. In state-analysis mode, a logic analyzer always operates synchronously. Because an analyzer's internal clock should be able to run at a maximum rate that's considerably higher than that of the fastest clock in the SUT, using the internal clock yields the instrument's best timing resolution.

When you use a logic analyzer to investigate glitches, you will almost invariably use it as a timing analyzer; state analysis isn't intended for glitch capture, and if you try to capture glitches with a logic analyzer in state-analysis mode, you will discover some significant shortcomings.

For example, consider the use of a logic analyzer in its state-analysis mode to monitor a  $\mu$ P-based system's state at the end of each instruction cycle. If each instruction cycle requires many clock cycles, then legitimate state transitions during each clock cycle can fulfill the glitch criterion, resulting in an inappropriate glitch indication from the logic analyzer.

Some logic analyzers allow you to operate a portion of their channels in state-analysis mode while you use the remaining channels for timing analysis. Sometimes,

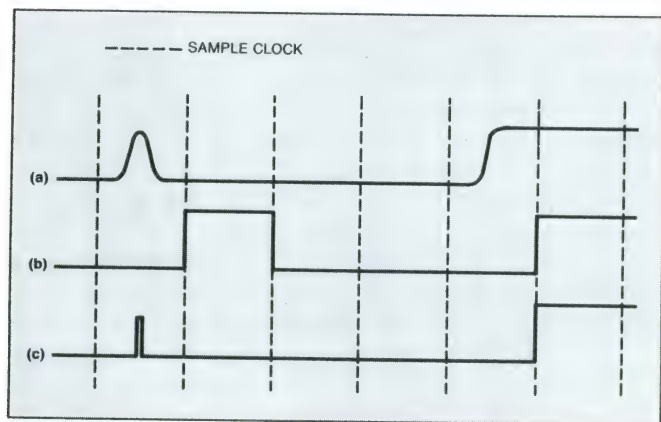
*If you try to capture glitches with a logic analyzer in state-analysis mode, you will discover some significant shortcomings.*

augmenting a timing display with a state display can help you to determine if a glitch is the probable source of a system malfunction.

At first, glitch capture might seem unnecessary because if you don't use it and you make the sampling interval shorter than the narrowest glitch the SUT can produce, you can guarantee that you will catch all glitches. (The narrowest glitch is approximately equal to the propagation delay ( $t_{PD}$ ) of the logic family used in the system under test.) However, with this scheme, a glitch is likely to look like a legitimate logic state on the analyzer's display.

Furthermore, because few systems operate at clock rates approaching the reciprocal of  $t_{PD}$ , attempting to set the logic analyzer's clock rate to greater than  $1/t_{PD}$  is likely to require you to use a very-high-speed (and thus very expensive) analyzer, one that costs considerably more than an analyzer whose sampling rate you chose on the basis of the clock rate of the SUT. Another problem is that setting an analyzer's internal clock to a high rate to capture glitches limits the number of SUT states the instrument's memory can store.

Glitch-capture circuits arose as an alternative to the use of high-speed analyzers to detect glitches in low-speed systems. However, such circuits can't capture all glitches. Moreover, even though your analyzer might tell you that a glitch has occurred during a particular sampling interval, it cannot tell you the duration of the glitch, its amplitude, its shape, or its precise timing within the interval. That missing information may be exactly what you need to isolate the cause of the anomaly.



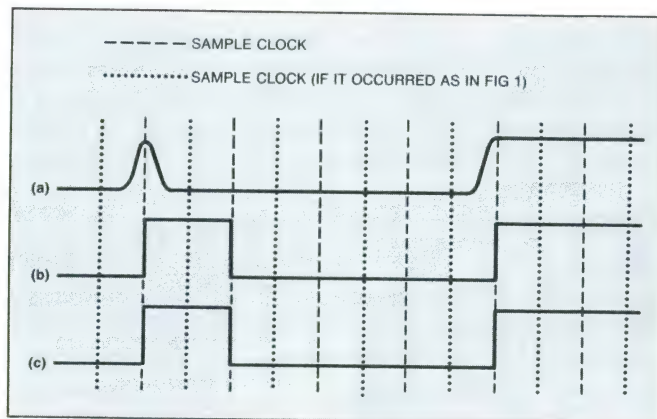
**Fig 1—When a glitch occurs in the middle** of a sample period (a), a latch-mode display (b) depicts it as a normal logic state existing for the entire subsequent sample interval. The second-order glitch-capture circuit and associated display (c) provide a more nearly accurate picture.

In addition to the effect of the sampling interval, several other factors influence a logic analyzer's glitch-capture capabilities:

- The ability of the analyzer's probes and front-end circuits to pass narrow glitches to the glitch detectors
- The response time and recovery time of the detectors
- The criteria the analyzer uses to recognize a glitch
- The amount of memory required to store glitch information and whether the analyzer sacrifices channel capacity or memory depth to obtain it
- Acquisition-speed limitations imposed by the speed with which the logic analyzer can write glitch information to its memory
- The format used to depict glitches on the display.

### Bad timing can fool glitch detectors

In some analyzers, the glitch-capture circuitry for each channel consists of a simple latch that is set the first time the associated input signal changes state within a given sample interval. This scheme, however, exhibits two problems: First, two or more transitions through the analyzer's threshold should be required to cause the analyzer to record a glitch, but only a single transition is needed to set the latch. Second, an analyzer using a simple latch displays the glitch in a sampling interval subsequent to the one in which it was detected. (Some logic analyzers make it appear as though a glitch state exists for the entire interval following the one in which the glitch occurred.)



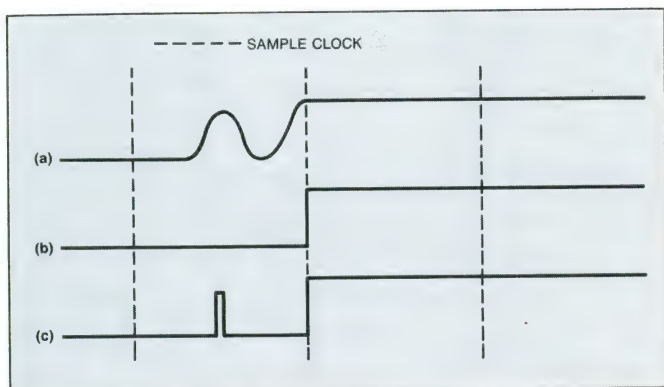
**Fig 2—If sampling occurs at the same time** as a glitch (a), the latch-mode display (b) looks just like the one resulting from sampling before the glitch. With second-order glitch capture, the display (c) looks the same as that caused by a normal state having a single-sampling-interval duration.

Some older logic analyzers—units with so-called latch-mode display—exhibit both of these glitch-capture and display defects. For the cases shown in **Fig 1b** and **Fig 2b**, such instruments produce similar displays. For the case shown in **Fig 3**, the glitch has the same polarity as the logic state at the next sample, and the latch-mode analyzer's display (**Fig 3b**) gives no indication of the glitch. **Fig 4** shows the same signal as that in **Fig 3** sampled at slightly different points. (Because sampling is asynchronous with the signal, the exact location of the sampling points is random.) In **Fig 4b**, normal sampling occurs in the middle of the positive glitch, but the latch detects what appears to it as a negative glitch. Therefore, the latch causes the analyzer to display a logical-0-state glitch. Although the glitch *does* show up, the display doesn't indicate whether a positive glitch preceded a normal 0-to-1 transition or a negative glitch followed such a transition.

### Glitches can masquerade as normal states

Although they do not depict glitches as logic states lasting a full sample interval, many analyzers that incorporate second-order glitch capture still provide a potentially misleading display. For example, when such analyzers find a glitch, they display a narrow pulse in the middle of the sample interval during which they detected the anomaly. The pulse displayed has a state opposite that found on the data line at the sample time preceding the glitch.

**Figs 1c, 2c, 3c, and 4c** show examples of second-order glitch displays. Note that in **Fig 2c**, because normal sampling happened to take place at the same time as the glitch, the analyzer displays the glitch as a normal logical 1 with a duration of one sample interval.



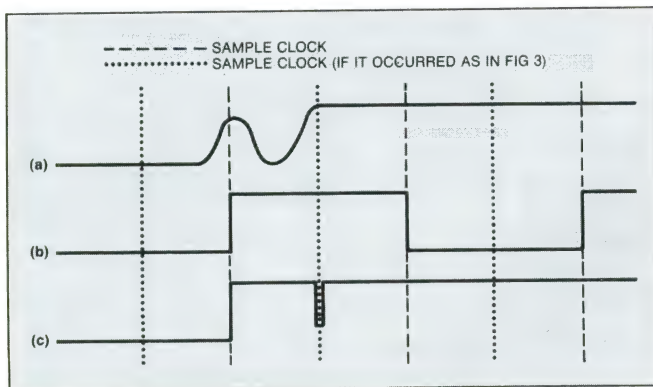
**Fig 3**—If the logic state at normal sample time is the same as that of a preceding glitch (a), the latch-mode display (b) completely fails to show the glitch. The second-order glitch display (c) does indicate the transient.

**Fig 2c** shows that the second-order display can present some glitches as normal logic states. More often, however, the second-order display implies a particular glitch amplitude, duration, and timing, although neither you nor the analyzer has much basis for drawing conclusions about the precise nature of these glitch parameters. To indicate the indeterminate nature of a signal during sampling intervals in which glitches are detected, some analyzers display glitches as shaded signals.

The situations illustrated in **Fig 3b** and **Fig 4b** (where the analyzer sometimes catches a glitch and sometimes misses it) or by **Fig 1c** and **Fig 2c** (where the analyzer sometimes displays the glitch as a glitch and sometimes displays it as a normal logic state) demonstrate the need to make repeated measurements when you suspect that your analyzer may be missing glitches or improperly displaying them. If you have a situation in which the glitch always occurs, but the logic analyzer sometimes fails to catch it, or sometimes displays it incorrectly, you ought to be able to find the glitch after a short period of repeating the measurement. If the glitch itself occurs only on rare occasions, you really need to use techniques that will display it correctly every time it occurs. Otherwise, you will probably spend an inordinate amount of time trying to spot it.

### Determine what led to the glitch

Some analyzers offer the option of triggering on glitches or of halting data acquisition when they detect a glitch. Because a logic analyzer generates its display from data stored in its memory, a glitch-triggered display can be a very powerful tool for collecting the information you need to determine the cause of and cure



**Fig 4**—When normal sampling and a positive-polarity glitch occur simultaneously (a), the latch-mode glitch detector can be fooled into detecting a negative-going glitch (b) after the real glitch. The second-order glitch detector (c) provides a fairly accurate representation.

*On some logic analyzers' displays, a glitch looks much like a legitimate logic state.*

for intermittent malfunctions. Once you have determined approximately when the glitch is likely to occur, glitch triggering allows you to repeatedly run the SUT and halt data acquisition or trigger the logic analyzer so that it displays the sequence of events that preceded the glitch. However, before you rely too heavily on a logic analyzer's glitch-triggering capability, you should understand the circumstances that can cause the instrument to fail to trigger on a glitch.

To be truly useful in your detective work, a logic analyzer's glitch-triggering capabilities should allow you to trigger the analyzer whenever a glitch occurs on any of its inputs (that is, the logical OR of all the unit's glitch detectors). An even better arrangement lets you specify which inputs to include in the glitch-triggering expression. Although glitch triggering doesn't tell you a glitch's amplitude, shape, or precise timing, there's a good chance that the screen display it provides contains the information you need to isolate and correct the problem.

#### In $\mu$ P systems, check interrupt lines

In  $\mu$ P-based systems and other synchronous logic, many lines are relatively insensitive to glitches; they respond to data only at system-clock edges, and clock edges represent a small percentage of total time. Furthermore, if it's to have an effect on the system, data on these lines usually must be present for tens of nanoseconds. Other lines—interrupt lines are a good example—can respond to signals that appear at any time. Frequently, these lines are sensitive to pulses only a few nanoseconds wide.

Sometimes, if you disable interrupts, you can determine whether a glitch on an interrupt line is the source of a system malfunction. Of course, in order to learn anything useful, you have to understand how the system is supposed to behave with interrupts disabled. If you suspect that a glitch on an interrupt line is causing your problem, and your logic analyzer allows a combined state/timing display, then once you have located the point in time when the troublesome glitch seems to be occurring, you can use the state analyzer to check whether or not interrupts are actually enabled.

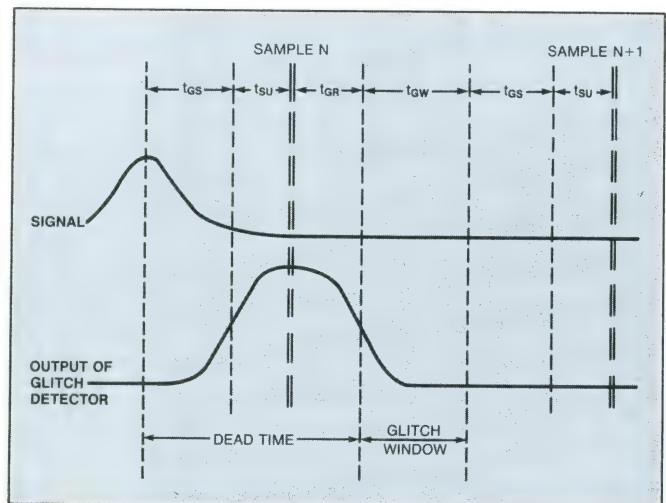
Setting a logic analyzer's sample rate too high can cause glitches to masquerade as normal logic states, but on the other hand, insufficient bandwidth in a logic analyzer's glitch-capture circuits can cause the instrument to miss glitches.

Although a logic analyzer is a digital device, its ability to capture glitches depends strongly on circuit

elements that are primarily analog in nature. A logic-analyzer channel's input consists of a probe, a buffer/amplifier, a comparator, a line driver, and a delay line. (The vendor adjusts the delay line to compensate for timing skew between channels.) Together, these elements determine the width of the shortest pulse the analyzer can detect. For glitch capture to be effective, this pulse must be considerably shorter than the sampling interval used; otherwise, the analyzer will be unable to recognize when an input signal makes two or more transitions within a sampling period.

Sometimes, the logic-analyzer manufacturer finds it prohibitively expensive to include circuit elements that permit glitch capture at the logic analyzer's maximum sample rate. You should check your analyzer's specs to find out whether the glitch capture will function at all sample rates; if it doesn't, you should determine the maximum sample rate at which the glitch capture functions or the minimum glitch width that the analyzer's specs say it can detect.

With a little information about your analyzer's glitch-capture circuits, you can make a rough calculation of the probability that the instrument will be able to capture glitches under a particular set of conditions. The results of the calculation may disappoint you. Fig 5 shows the timing considerations involved in the calculation. If the analyzer is to be able to separate a glitch from a normal transition, the glitch must precede the sample time by the glitch-setup time,  $t_{GS}$ , plus the data-setup time,  $t_{SU}$ .



**Fig 5—When an analyzer with glitch detection samples at a rate that approaches the reciprocal of the sum of the glitch detector's data-setup, glitch-setup, and glitch-reset times, the fraction of the time that the glitch detector can discriminate between a glitch and a normal logic state becomes very small.**

If a glitch arrives soon enough, it will be detected, and the fact that it occurred will be stored in the analyzer's memory. Until it is reset, the glitch detector cannot recognize another glitch.

The glitch detector's reset time is denoted by  $t_{GR}$ . If you take the sum  $t_{GS} + t_{SU} + t_{GR}$ , you have a total dead time during which the glitch detector is unable to detect a glitch. If you now subtract the dead time from the total sample time, you have the glitch window,  $t_{GW}$ , the time when the analyzer can recognize glitches. If you then take the ratio of  $t_{GW}/t_{SAMPLE}$ , you have the fraction of time during which the analyzer can catch glitches—a rough measure of the likelihood that the analyzer can catch a glitch.

Storing the information that a glitch was detected on an input line in a particular sample interval takes more memory than simply storing the 1 or 0 state of the input. Memory isn't free, of course. So, rather than dedicating memory to storage of glitch data, most logic analyzers with glitch-capture capability allow you to obtain glitch memory from the analyzer's normal data memory.

Some instruments obtain glitch memory by reducing the number of operating channels; others reduce memory depth. When you aren't looking for glitches, you can use all the memory to store normal data. Both methods of obtaining glitch memory are compromises, and neither is perfect. If you reduce the number of channels, you will probably have to rearrange the probes that connect the analyzer to the system under test and stop displaying some channels that have potentially important data. With reduced memory depth, you may not be able to display enough states at once to obtain a good picture of what is going on.

### Combine logic analyzer and digital scope

If your logic analyzer has glitch triggering and can trigger another device, then, after you've narrowed down to one or two the number of lines that might be susceptible to a glitch, you may want to examine the suspect lines with a digital storage oscilloscope. The scope, of course, has far fewer channels than the logic analyzer does, but it can display waveforms in detail—something the logic analyzer can't do.

Although the scope's trigger capabilities are less flexible than the logic analyzer's, you can compensate for that shortcoming by using the logic analyzer to trigger the scope. (You will almost certainly need a digital scope: The analyzer may produce its trigger output many sample periods after its input signals

satisfy the trigger conditions, and the scope therefore will have to display data it acquired before it received the trigger. Many digital scopes can provide the necessary signal delay; few, if any, analog ones can.) Although setting up both a scope and a logic analyzer to monitor the system under test may seem like a chore, the combination may reward you with a picture containing more information about the troublesome transient than you could obtain using either instrument alone.

If, at any point in your troubleshooting, you feel frustrated by a seeming lack of progress, a close examination of your system's schematic should be high on your agenda. It is important to understand which lines are likely to be susceptible to glitches, when they are susceptible, and the polarity and duration of glitches that can cause problems. For additional clues about the nature of the problem, you should consult device data books for detailed information about subtle properties of the ICs in your system.

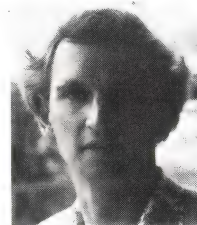
The bottom line is that tracking down glitches isn't simple. You shouldn't assume that a logic analyzer that incorporates glitch-capture capability can always find the glitch you are looking for. If you fail to determine just what the analyzer can and can't do for you, you greatly increase the chances that your troubleshooting task will be tedious and unpleasant. Moreover, if you embark upon the task without a thorough understanding of the operation of your system and the characteristics of the components it uses, you may be setting yourself up for failure.

**EDN**

---

### Author's biography

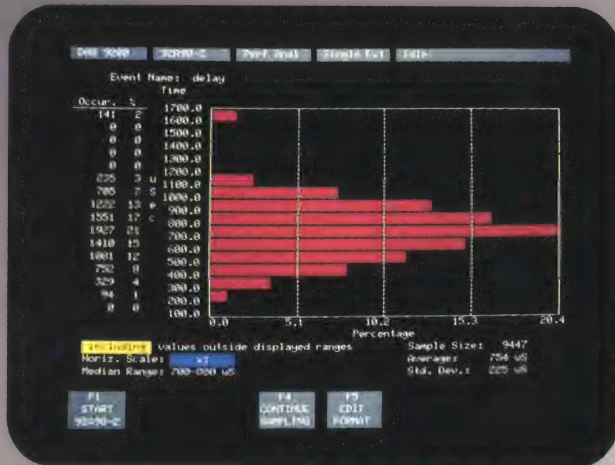
Wolfgang Schweitzer is a sales-support engineer in the international department of Kontron Messtechnik in Echting, West Germany. He is responsible for introduction and promotion of Kontron's line of  $\mu P$ -based instrumentation in northern Europe and Asia. Before he joined Kontron in 1981, he worked with Texas Instruments Germany. He is a member of Greenpeace and enjoys music, travel, skiing, and scuba diving.



---

Article Interest Quotient (Circle One)  
High 485 Medium 486 Low 487

# DAS9200 DIGITAL ANALYSIS: NOW TEK MAKES THE IMPOSSIBLE LOOK EASY.



Software Performance Analysis, like this distribution of a subroutine's execution times, helps you easily understand the activity of your code.

Seq	Address	Data	Mnemonic	State
6597	main + 2F7C	4E99	JSR ser_io	(U)
6791	ser_io + 84	61FC	BSR put_byte	(U)
6871	put_byte + 42	4E75	RTS	(U)
9680	ser_io + 1206	4E99	JSR ser_io	(U)
11699	delay + 76	4E75	RTS	(U)
11796	ser_io + 1324	61FC	BSR com_tst	(U)
11899	com_tst + 76	4E75	RTS	(U)

Seq	Address	Data	Mnemonic	State
14697	io_int + 1C8	200F	MOVL (A7)+,D3	(S)
	0AFB28	0000	( READ )	(S)
	0AFB28	0040	( READ )	(S)
14699	io_int + 1C2	211F	MOVL (A7)+,D4	(S)
	0AFB28	0000	( READ )	(S)
	0AFB28	0040	( READ )	(S)
14701	io_int + 1C4	4E73	RTE	(S)

Step backwards through acquired data, including sub-routines, stack and register models, using time-correlated split-screen displays to pinpoint problems.

In every dimension—speed, channel width, memory depth, trigger capability, modularity and ease of use—the DAS9200 dwarfs what's been possible before.

The DAS9200 features a tightly coupled, high-speed architecture in which multiple card modules can act as a single unit. Large color-coded displays, pop-up menus, performance analysis graphs,



multi-tasking and more combine to take logic analysis to levels like these:

# **1 State-driven triggering at 200 MHz.**

You can use up to 384 channels of sync and async data acquisition. You can assure-test high-speed logic at full speed, using 4-level state tracking and high-speed counter/timers. You can monitor and verify all timing measurements in a circuit.

# **2 Symbolic, real-time software debugging.**

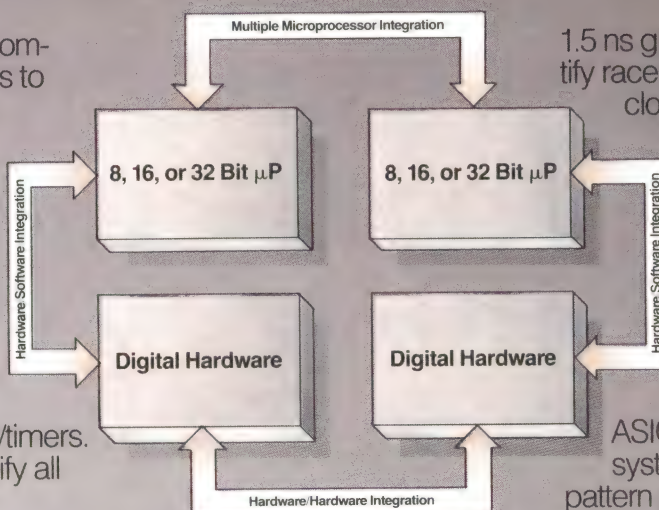
Register deduction and stack simulation let you pinpoint problems like stack overflow or incorrectly restored pointers—without breakpoints or manual notation.

# **3 Simultaneous integration of up to six micro-processors.**

Use the dual timebases and real-time handshaking between system modules to set up split-screens displays that scroll in precise time alignment.

# **4 160 channels of acquisition at 2 GHz.**

Use up to 500 ps sample interval and



1.5 ns glitch detection to identify race conditions, spurious clocks and setup/hold violations in any logic family. System probes feature input capacitance of <1 pf.

# **5 Easy ASIC verification at up to 50 MHz.**

The DAS9200 is available as a low-cost turnkey ASIC device verification system. Featuring 50 MHz pattern generation, 8K bit vector depth, and 1 ns edge placement, it offers the power, precision and simplicity to be an attractive alternative to centralized systems.

# **6 Stop wishing for the impossible in digital analysis:**

Compare your wish list against the complete list of DAS9200 capabilities. Contact your Tek sales engineer, or call toll-free for more information.

**Call 1-800-245-2036.**

In Oregon, 231-1220.

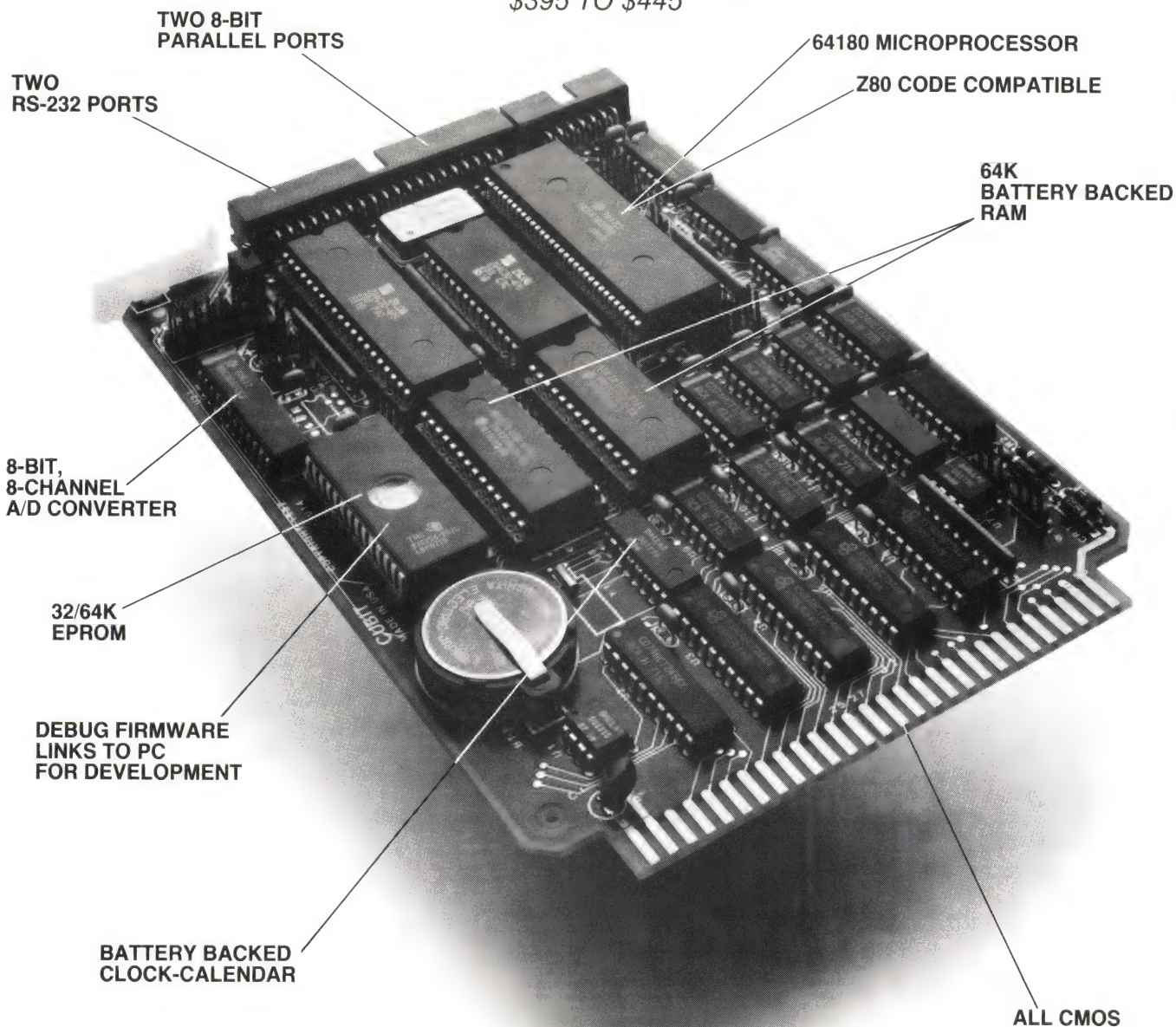


Available in desktop and rack-mount versions, the DAS9200 mainframe can be augmented with up to three expansion mainframes for a total of 28 card slots.

**Tektronix®**  
COMMITTED TO EXCELLENCE

# CμBIT STD BUS FOR INDUSTRIAL CONTROL

*Cubit Model 8020 CPU Board—  
\$395 TO \$445*



**CμBIT** DIVISION  
OF  
PROTEUS  
INDUSTRIES

190 South Whisman  
Mountain View, CA 94041-1577  
(415) 962-8237

CIRCLE NO 39

# Integrated PLDs support Multibus II bus arbitration

---

*The incorporation of buried state registers in PLDs makes the devices suitable for the design of sequential machines. Such devices thus provide compact packages for containing the bus-arbitration logic in Multibus II systems.*

---

Arthur Khu, *Advanced Micro Devices*

In multiprocessor environments, data transfers occurring over a common bus must be coordinated so that only one peripheral at a time can place data on the bus. Any peripheral that needs to transfer data to another board in the system must request access to the bus, and it must contend for control of the bus with other requesting units. Bus-arbitration schemes determine which requesting unit gains control.

In a synchronous Multibus II system, bus arbitration is decentralized. Requesting boards use a back-off algorithm (see **box**, "Back-off algorithm for Multibus II bus arbitration") to mutually resolve concurrent bus requests, and lower-priority requesters defer to the requesting unit with the highest priority. This scheme makes a dedicated bus-arbiter unit unnecessary, thereby reducing the amount of logic in the Central Services Module (CSM), which every Multibus II system includes.

Because every Multibus II board that's capable of

controlling the bus must contain the same arbitration logic, it behooves the designer to integrate these functions into as few devices as possible to reduce cost and space requirements. Fewer devices also minimize the interconnections between ICs.

The bus-arbitration logic requires four interrelated state machines, which PLDs can readily implement. The AmPAL23S8 is particularly suited for this application because it contains six buried state registers (see **box**, "Compact building blocks for arbitration logic"). Therefore, you can implement all four state machines in one PLD, and you can use the AmPAL23S8 in tandem with an AmPAL22P10, programmed with the back-off algorithm, to contain most of the logic necessary to implement the Multibus II arbitration and transfer protocols.

## Bus arbitration in a Multibus II system

In a Multibus II environment, a board that interfaces to the system bus is known as an agent. At system reset, the CSM (which also generates time-out and clock signals) assigns to each agent an arbitration-priority ID. You can set the arbitration priority of the board by reprogramming the ID that the CSM assigns.

Agents use this ID to arbitrate for control of the bus before transferring data. The agents monitor six arbitration signal lines, ARB0(L) through ARB5(L), to mutually determine the highest priority requesting agent to get first access to the bus. Note that the convention for denoting an active-low signal is to use an (L)—eg, ARB0(L).

When the bus-request line BREQ(L) is inactive—set

Multibus II bus-arbitration logic requires four interrelated state machines.

high, denoted by (H)—a requesting agent can drive the bus-request line and put its arbitration ID on the ARB lines. If more than one agent requests access to the bus simultaneously, the lower-priority agents defer to the highest priority agent in the requesting group. After this agent releases the bus, the other agents that generated bus requests concurrently are serviced sequentially, based on their priority. This series of arbitration operations, where bus control is granted sequentially to simultaneous requesters, is called a bus-request sequence.

The requesting group locks out all other bus requests until each agent in the group has gained access to the bus. (Note, however, that an agent assigned a high-priority ID—one that asserts ARB5(L)—can enter and participate in a bus-request sequence simply by putting its ID on the ARB lines, even when the BREQ(L) line is active.) Once the bus-request sequence is complete, the BREQ(L) line becomes inactive, and a new bus-request sequence can begin.

When an agent is contending for the bus, it needs to monitor several system control lines and operations.

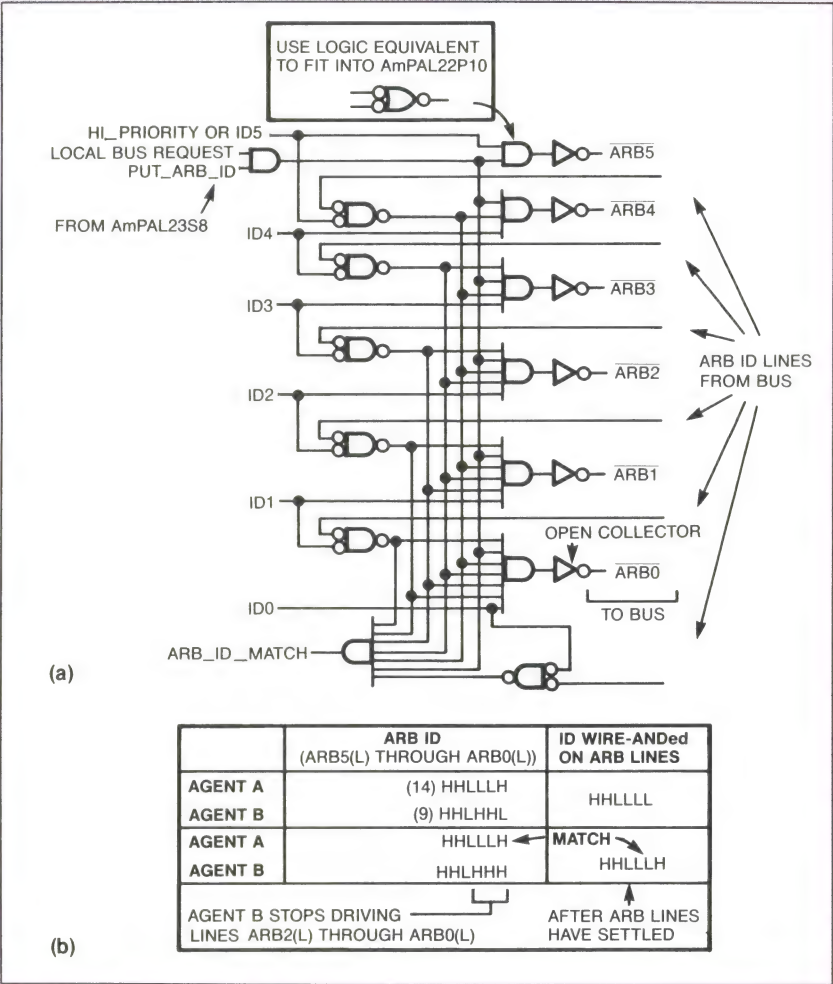
Back-off algorithm for Multibus II bus arbitration

All agents contending for access to Multibus II use the back-off algorithm. When an agent puts its arbitration ID on the bus ARB lines, the ID value is wire-ANDed with the other IDs driven onto the bus. Each contending agent monitors these ARB lines to determine whether it's the highest priority agent.

To make this determination, the contending agent compares each bit of its assigned ID (MSB to LSB) with the wire-ANDed value on the ARB lines. Combinatorial logic circuitry, which is present on each agent, forces the IDs of lower-priority agents to cease driving the ARB lines.

For example, if agent A has an arbitration ID (priority) of 14 and agent B has an ID of 9, then agent B stops driving the ARB2(L) line and all lines below ARB2(L).

The ARB lines are allowed three bus clock cycles to settle before they are used by the arbitration-monitor and -control state machines. An ARB ID MATCH command indicates that an agent has the highest priority and can take control of the bus on an EXCHANGE condition.



The back-off algorithm can be implemented with combinatorial logic circuitry (a). In the example of b, the lower-priority agent B backs off by ceasing to drive ARB lines 0 through 2.

Three state machines perform these monitoring functions:

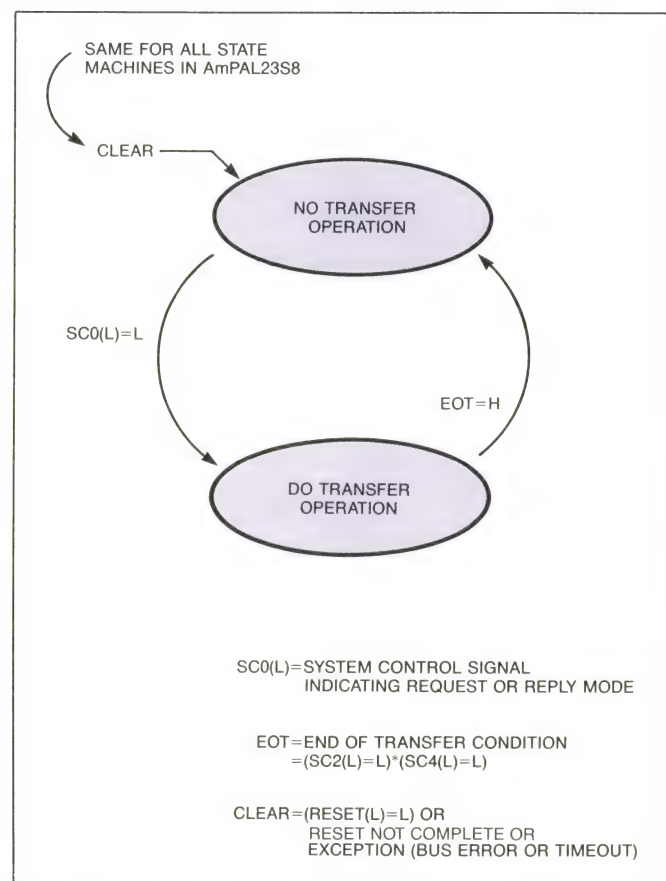
- A transfer monitor, which tracks all transfer operations taking place on the bus
- An arbitration monitor, which monitors all arbitration operations occurring on the bus
- An arbitration controller, which controls the requesting agent's arbitration operation.

Once an agent becomes the bus owner, a fourth state machine comes into play:

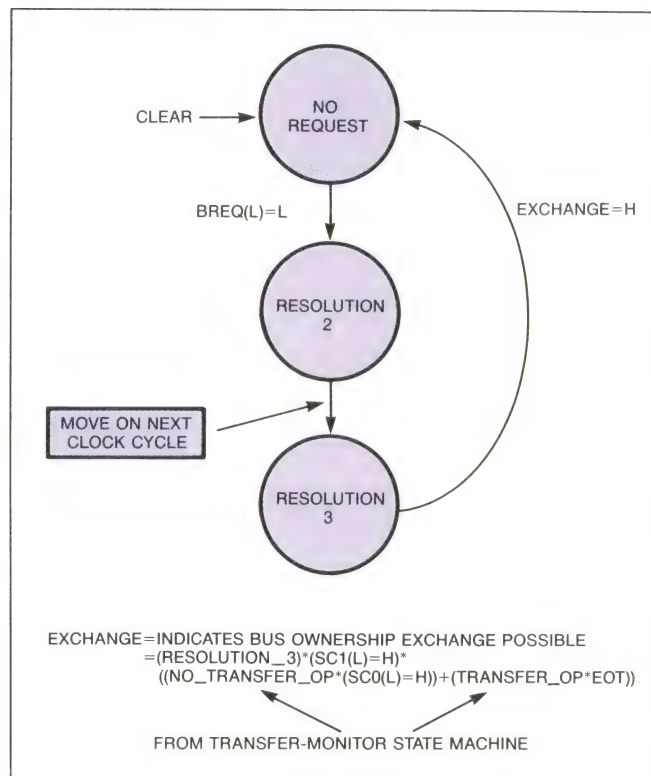
- A transfer supervisor, which supervises the data-transfer operation.

These four state machines are programmed into the AmPAL23S8 and are very closely coupled. Each state machine uses the status of the others to determine its next state.

All agents capable of initiating data transfers use the transfer-monitor state machine to continuously monitor the bus to detect any data transfers taking place (**Fig 1**)



**Fig 1—The transfer-monitor state machine monitors all data transfers taking place on the system bus. A transfer operation begins when SC0(L) goes low.**



**Fig 2—The arbitration-monitor state machine synchronizes the exchange of the bus.**

1). Whether or not data transfers are taking place on the bus is a condition that the other three state machines use when contending for control of the bus. The transfer monitor, a 2-state machine, monitors three system control lines called SC0(L), SC2(L), and SC4(L). A transfer operation begins when SC0(L) goes low, causing the machine's transition to the state labeled DO TRANSFER OPERATION. The transfer-monitor machine remains in this state until the last data transfer for the current operation is complete. When SC2(L) and SC4(L) go low, the machine detects an end-of-transfer (EOT) condition and changes to the NO TRANSFER OPERATION state.

### Arbitration monitor resolves conflicts

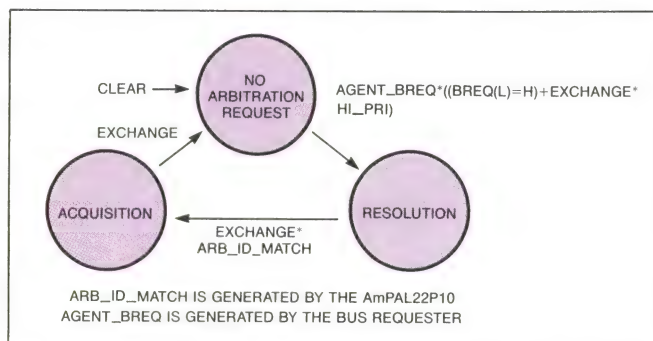
A bus-requesting agent must always monitor any arbitration operations taking place on the bus so that the agent can synchronize the granting and exchanging of bus ownership. To accomplish this function, the arbitration-monitor state machine counts three bus clock cycles after detecting that the BREQ(L) line has gone low (**Fig 2**). The state labeled RESOLUTION 3 occurs on the third bus clock (the ARB lines have three

*If more than one agent requests access to the bus simultaneously, the lower-priority agents defer to the highest priority agent in the requesting group.*

clock cycles to settle with the highest priority ID). All requesting agents remain in the RESOLUTION 3 state until a bus exchange is possible. The arbitration-state machine oversees the transfer-monitor machine and uses the equation for EXCHANGE shown in Fig 2 to determine whether the EXCHANGE conditions are fulfilled. When the EXCHANGE conditions are met, the machine makes the transition to the NO REQUEST state.

The arbitration controller controls the behavior of an agent when it's participating in arbitration. If a unit on the agent (for example, the CPU) needs to transfer data, the agent initiates a bus request (AGENT BREQ). The state machine enters the RESOLUTION state of arbitration if no current bus-request sequence is occurring (that is, if BREQ(L) is high), or if the current request sequence is ending (that is, if the bus can be exchanged on the next clock cycle) and a high-priority request is asserted (Fig 3).

In the RESOLUTION state, the arbitration-control



**Fig 3—The arbitration-control state machine controls an agent's bus requests. An agent acquires ownership of the bus when the EXCHANGE condition is met and when the agent's ID matches the ID on the bus-arbitration lines.**

machine sends a PUT ARB ID command to the combinatorial logic in the AmPAL22P10. Concurrently, the agent places its ID on the ARB lines. Using the status of the transfer- and arbitration-monitor machines, the arbitration-control machine waits in the RESOLUTION

## Compact building blocks for arbitration logic

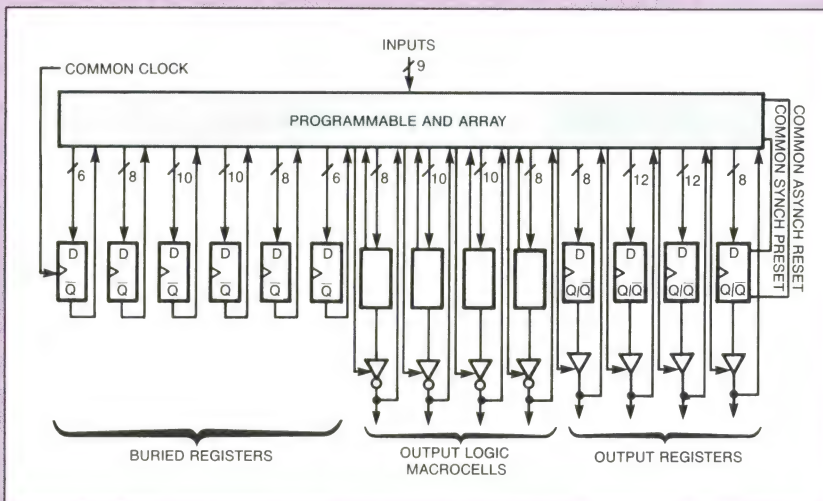
The AmPAL23S8 is a 20-pin programmable logic device capable of 33-MHz operation. It uses the sum-of-products (AND-OR) logic structure in conjunction with 14 on-chip state registers. The registers on the -23S8 provide a compact architecture for building the four state machines necessary to implement the bus-arbitration logic for Multibus II.

The device has six buried state registers, which give designers flexibility in designing sequence machines. The status of three of the four state machines for Multibus II is not needed by external units; therefore, the buried state registers provide convenient building blocks for these machines. The status of the fourth machine (the transfer-supervisor state machine) is required by other units; therefore, that machine can be

built around the I/O macrocells and output registers available on the chip.

Because the back-off algorithm only requires combinatorial logic, a programmable device

with a sum-of-products (AND-OR) logic structure is sufficient to implement the algorithm. The algorithm can be completely contained in a 24-pin AmPAL 22P10 chip.



**Sum-of-products logic and 14 on-chip registers make the AmPAL23S8 suitable for use in Multibus II arbitration. You can use the six buried registers to build sequential machines.**

state until the ID on the ARB lines matches its own ID (ARB ID MATCH) and the EXCHANGE condition is met. At least three bus clock cycles must occur in the RESOLUTION state before the agent can acquire bus ownership.

When the conditions are met, the arbitration-control state machine enters the ACQUISITION state and remains there until the bus transfers are complete. Fig 4's timing diagram shows the critical functions when two agents (A and B) simultaneously request control of the bus. Agent A has a higher priority than agent B.

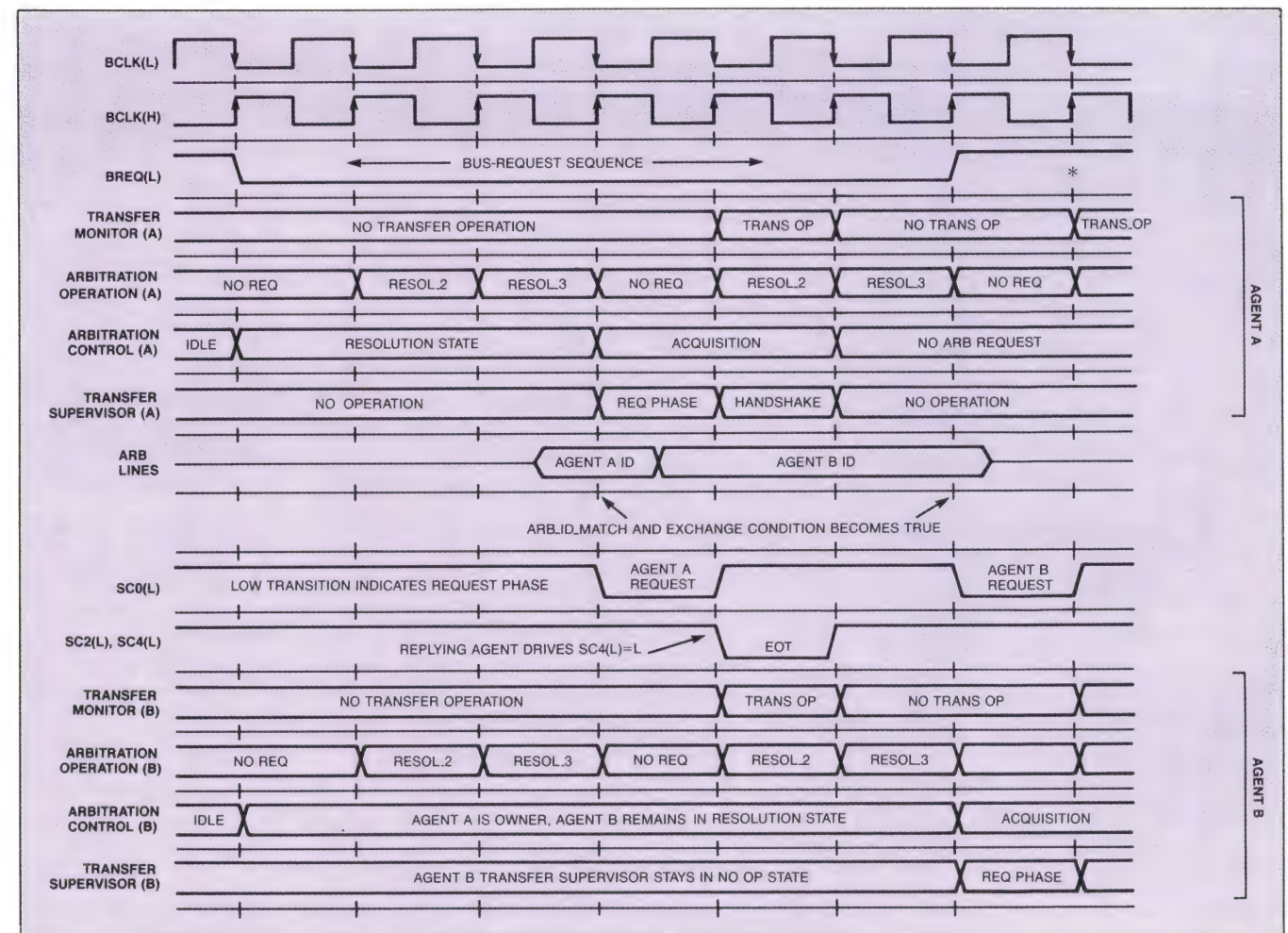
#### An agent can park the bus

In the ACQUISITION state, the agent owns the bus and can perform data transfers. The bus owner can ensure that it retains exclusive use of the bus by

asserting SC1(L). This lock signal prevents other agents from gaining ownership of the bus while the current owner performs consecutive transfer operations. On the last data-transfer handshake sequence, the agent asserts the system control line SC2(L), effecting an EOT condition.

If another agent contends successfully for use of the bus, the current bus owner will transfer bus control to the other agent. If no other agents request access to the bus, the EXCHANGE condition, as defined in Fig 2, isn't met, and bus control remains, or is parked, with the current bus owner. This parked condition allows the agent to perform another transfer operation without contending for the bus, thus reducing the data-transfer setup time.

The transfer-supervisor state machine supervises the



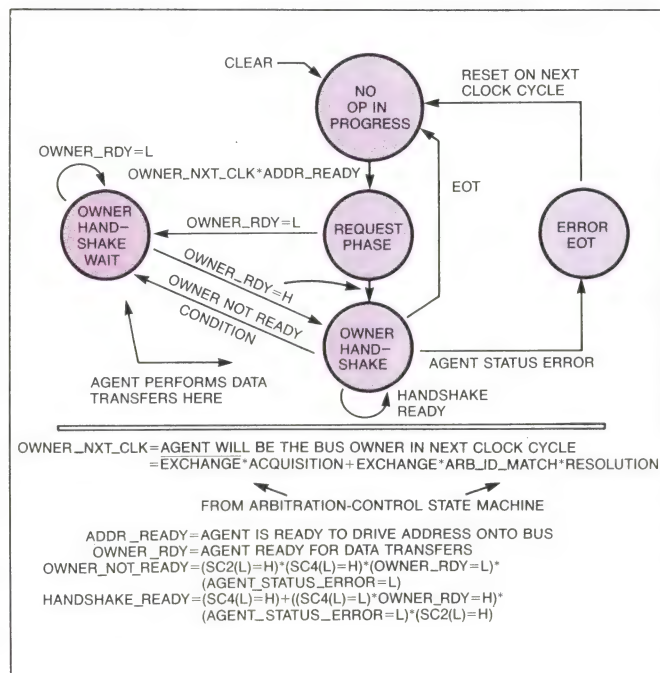
**Fig 4—When two agents simultaneously request bus ownership, the higher priority agent (A in this case) assumes control first. When A releases control, ownership transfers to B in an orderly sequence.**

*When an agent is arbitrating for the bus, it needs to monitor several system control lines and operations.*

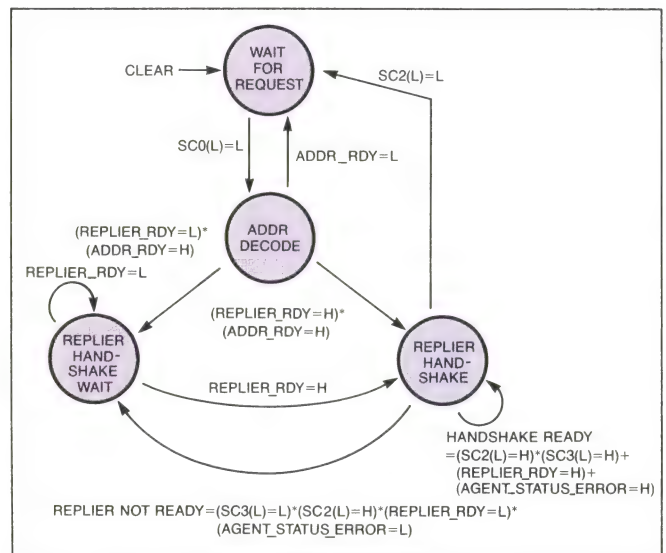
agent while the agent performs data transfers (Fig 5). Other functional modules on the agent's board use the status of this machine to generate the proper control signals. For example, the machine enters the REQUEST PHASE state when the agent becomes the bus owner and asserts the operation parameters (such as an address to read from or write to). In the REQUEST PHASE state, read or write requests to a replying agent take place via the system control lines, SC0(L) through SC7(L), and addresses are set up on the address lines, AD0(L) through AD31(L).

An address-generating unit (for instance, the CPU) drives addresses or data onto the 32 AD lines. This unit generates the address when the REQUEST PHASE status appears on the transfer-supervisor state machine's registers. On the next clock cycle, the transfer supervisor begins the transfer handshake operation. If the bus owner isn't ready to accept data (on read operations) or provide data (on write operations), the state machine enters a handshake-wait mode by waiting in the OWNER HANDSHAKE WAIT state until the owner is ready. The conditions for the state transfers are shown in Fig 5.

Asserting SC2(L) and SC4(L) effects an EOT condition, completing the transfer. The state machine returns to the NO OP IN PROGRESS state. If an error



**Fig 5—The transfer-supervisor state machine controls the data-transfer handshake protocol.**



**Fig 6—The repplier-transfer state machine manages the handshake logic in the replying agent to transfer data.**

occurs during a transfer, the block transfer terminates, causing an ERROR EOT state transition before returning to the NO OP IN PROGRESS state.

When a bus owner transfers data, the replying agent must perform the responding handshake sequence in compliance with its own repplier-transfer state machine. This 4-state machine monitors six system control lines and two of its own signals, ADDR READY and REPLIER RDY, to control state transitions (Fig 6). The repplier state machine requires two status-register bits, which are accessible to other units on the board. When the repplier-transfer state-machine registers indicate the REPLIER HANDSHAKE state, the other units on the replying agent generate the system status and control signals. The SC3(L) and SC4(L) control lines accomplish the handshake. The sending agent controls the SC3(L) line while the replying agent controls the SC4(L) line. When the transfer is complete, the sending agent sets the SC2(L) control line low, which ends the transfer because the replying agent has already set the SC4(L) control line low.

Programming the PLDs to implement the four state machines and the back-off logic is straightforward using a high-level language. Listing 1 shows the steps necessary to execute the arbitration-control state machine in AMD's Programmable Logic Programming Language (PLPL). The CASE statement defines which one of the four state machines is being programmed into the AmPAL23S8. Note the correspondence of the statement sequence with the respective state diagram.

# MULTIPLE CHOICE



With Every Standard KEC Power Supply You Get:

FEATURE	BENEFIT
Standards Approval	Meets or exceeds all International standards approvals (UL, VDE, CSA, and TUV)
Product Range	Over 200 standard precision switching power supplies ranging from 25W to 1 KW
Price	Extremely competitive to meet your volume requirements
Warranty	2-year return to factory
Reliability	Consistently achieves less than 1/10th of 1 percent field returns
Size and Performance	Compact size with up to 100 KHz switching speed

It's easy to choose the exact KEC power supply to meet your requirements. Select from over 200 products or have KEC's engineers custom design a precision switching power supply just for you.

Choose from both open frame or modular styles, in a wide range of wattages. You also have a choice of 115 or 230 VAC inputs. KEC assures prompt delivery from its California warehouse.

When you choose a KEC power supply, you get over 70 years of design engineering experience dedicated to creating a standard for you.

Discover the real Multiple Choice in power supplies—Discover KEC! Write for your FREE literature and information kit, or call KEC toll-free today.

## 1-800-255-5668



**KEC ELECTRONICS, INC.**  
20817 Western Avenue, Torrance,  
CA 90501  
(213) 320-3902, FAX (213) 618-1197

**"KEC—BRINGING MORE POWER TO YOU"**

*Programming the PLDs to implement the four state machines and the back-off logic is straightforward using a high-level language.*

#### LISTING 1—ROUTINE FOR ARBITRATION-CONTROL STATE MACHINE

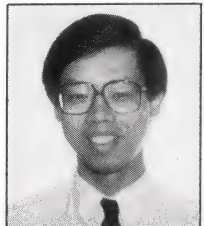
```
"ARB_OPER: 2-bit state machine in all requesting agents
that controls the arbitration operation -----"
case (arb_oper[1:0])
begin
  NO_ARB)
    begin "agent wants bus and there is no current bus req"
      if (breq*(/bus_req + EXCHANGE*hi_pri)) then
        begin
          put_bus_request = 1; "assert bus request"
          arb_oper[1:0] = RESOLUTION_STATE;
          end;
        else
          arb_oper[1:0] = NO_ARB;
          end;
      RESOLUTION_STATE)
        begin
          put_arb_id = 1;      "put arbitration ID on ARB lines"
          if (EXCHANGE*arb_id_match) then
            arb_oper[1:0] = ACQUISITION_STATE;
          else
            begin
              arb_oper[1:0] = RESOLUTION_STATE;
              put_bus_request = 1; "continue asserting bus request"
            end;
          end;
        ACQUISITION_STATE)
          begin
            if (EXCHANGE) then
              arb_oper[1:0] = NO_ARB;
            else
              arb_oper[1:0] = ACQUISITION_STATE;
            end;
          end; "ARBITRATION OPERATION state machine"
```

Because logic equations specify the four state machines, the machines can operate in parallel in a PLD. Once the status of a state machine is updated, it is immediately available to the logic equations for the other state machines on the same PLD.

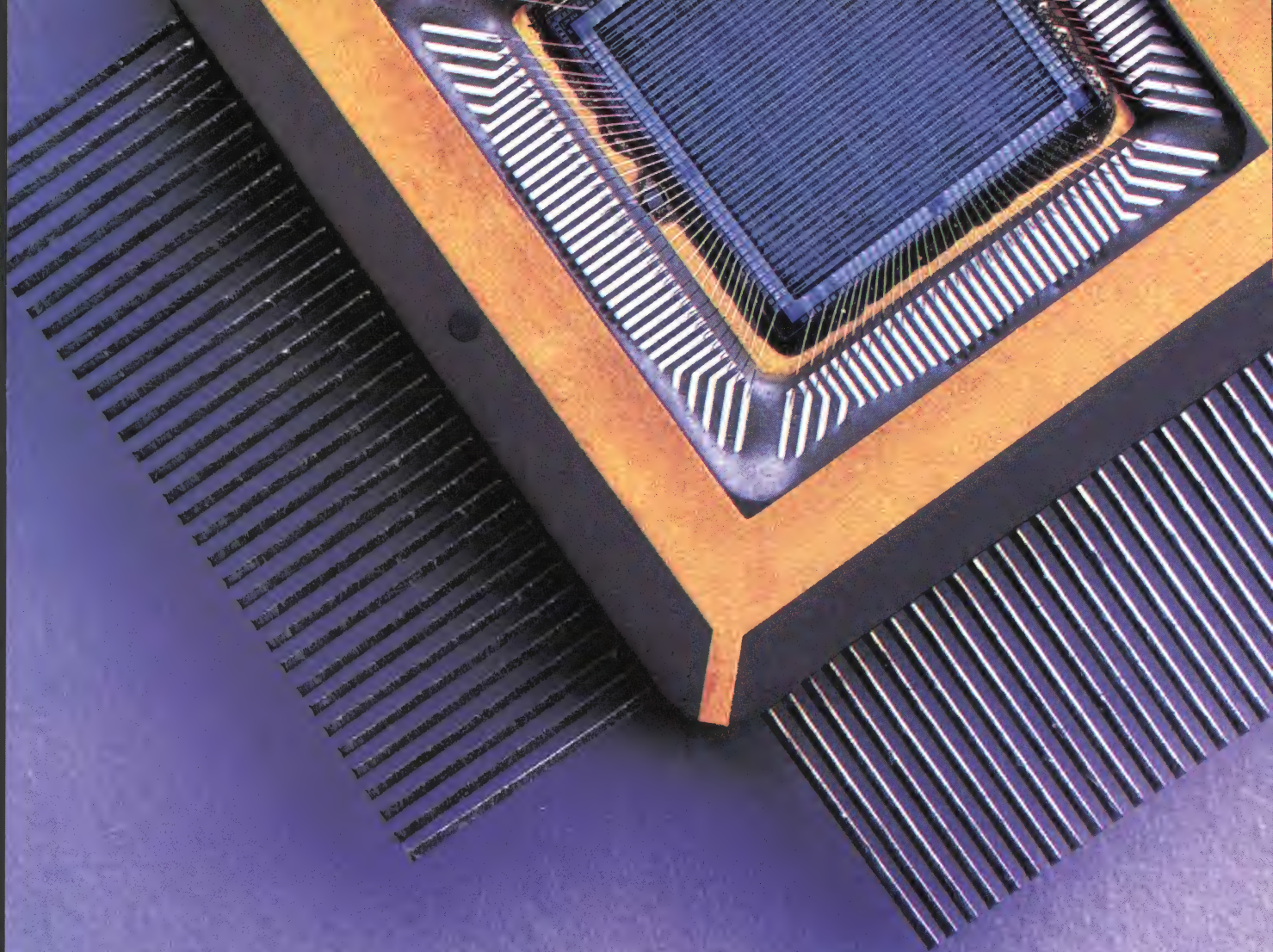
For example, if a transfer operation is detected on the bus (that is, SC0(L) is active), the transfer monitor moves to the DO TRANSFER state on the next clock cycle. The other state machines in the device immediately sense this state transition via output feedback. Any logic equation using the transfer-monitor status, such as EXCHANGE in the arbitration-monitor machine, is automatically updated for the next clock cycle. All of the other conditions are updated in parallel, making them current on the next clock cycle. **EDN**

#### Author's biography

*Arthur Khu is a senior product planning engineer with Advanced Micro Devices in Sunnyvale, CA, and has worked with the company for three years. He presently researches and develops advanced logic-device architectures and design tools. Art holds a BS in math and computer science and an MS in computer science from Santa Clara University. In his spare time he enjoys racquetball and reading about technological history.*



Article Interest Quotient (Circle One)  
High 497 Medium 498 Low 499



# A rad-hard gate array with only one set of standards. Military.

Our UTB-R radiation-hardened gate array family is born to the highest military standards. It is functional to a total dose of  $10^6$  rads (Si) and operates to data sheet specifications at  $2 \times 10^6$  (Si) rads.

Producing gate arrays for military and aerospace customers is nothing new to UTMC. For years we've been providing high-reliability ICs for divisions of United Technologies Corporation.

Screened to selected tests in MIL-STD-883C, the UTB-R family's patented continuous-column architecture

increases density without sacrificing routability. It uses transistors to isolate signals and allows you to get up to 95% gate utilization.

We combine high speed with low-power consumption of CMOS double-level-metal technology. And, our VAX®-based HIGHLAND<sup>SM</sup> Design System, which supports front-end design on major workstations, enables maximum design flexibility.

Equivalent 2-input NAND gates range from 1,000 to 7,600, and package options include DIPs, LCCs, PGAs, and Cerquads.

Don't compromise your standards. Choose the rad-hard gate array born to the military—the UTB-R Series.

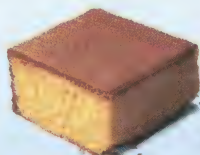
United Technologies  
Microelectronics Center  
1575 Garden of the Gods Road  
Colorado Springs, CO 80907  
1-800-MIL-UTMC



**UNITED  
TECHNOLOGIES  
MICROELECTRONICS  
CENTER**

# Sweet 16! (MHz)

## Our new static CMOS 80C286!



### Low power is the icing on the cake.

Now you can have your cake and eat it too: a 16 MHz high-throughput microprocessor with low CMOS power consumption.

Complete compatibility with the NMOS 80286: same pinout, same advanced multitasking architecture, same instruction set, same software. But with 16 MHz performance and a 60% reduction in operating power.

Static CMOS design eliminates trade-offs required by NMOS microprocessors. You get top-end throughput (@ 10, 12.5, or 16 MHz) when you need it or you can stop our 80C286 and put your system into standby without

fear of data loss or instruction execution errors. In either case, the Harris 80C286 has the lowest power requirement of any 80286.

Designed with multitasking in mind, the 80C286 is an exceptional performer in real-time control, portable instrumentation and data acquisition applications. And, coupled with our 80C86, 80C88 and F.O.R.C.E.-based microprocessors for distributed processing, the 80C286 is a great host.

Contact Harris about samples today. Write Harris Systems Ltd., Semiconductor Sector, Eskdale Road, Winnersh, Wokingham, Berks, RG11 5TR, England. Phone 0734-698787.



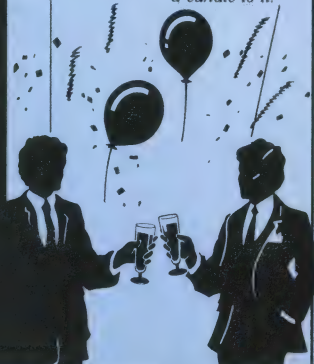
IN MICROPROCESSORS,  
THE NAME IS  
**HARRIS**

Harris Semiconductor: Analog - CMOS Digital  
Gallium Arsenide - Semicustom - Custom



**HARRIS**

"16 MHz and CMOS  
power savings..." "NMOS can't hold  
a candle to it!"



# Micropower op amp offers simplicity and versatility

---

*An op amp whose input range includes both supply rails and whose output voltage swings within 100 mV of those rails can simplify a circuit by eliminating certain traditional components.*

---

Zahid Rahim, Signetics Corp

Linear circuits intended to meet the stringent demands of medical and industrial instrumentation, remote data acquisition, and portable equipment must deliver precision at low voltages. A low-power, battery-operated op amp, for instance, requires precision dc characteristics to process low-level signals from high source impedances, low supply current to conserve power, and wide bandwidth to process audio-frequency signals. Because low-voltage applications produce low signal levels, the op amp should have a wide dynamic range at the input and output. Moreover, both it and its external circuit should function properly at the end-of-life battery voltage.

The NE5230 op amp is suited to such requirements. It operates from a supply voltage of 1.8 to 15V and performs well in systems powered by single 5V supplies. The op amp not only offers precision dc characteristics, its common-mode voltage can swing within 100 mV of either supply rail—a characteristic matched by few other commercially available op amps.

Furthermore, the bias-adjust terminal lets you adjust the op amp's slew rate from 90 to 250V/msec by varying the op amp's internal bias currents. The device

also offers decent performance in two other parameters of concern in low-power applications—noise and output-current drive. The NE5230's input voltage noise is 22 nV/√Hz at 1 kHz, and it can source and sink 5 and 11 mA, respectively, when operating from a 1.8V supply at 25°C. Other key specifications are listed in Table 1.

These attributes allow you to use the op amp in battery-powered applications such as half-wave and full-wave rectifiers, window detectors with rail-to-rail input ranges, temperature-limit alarms, sound-activated intrusion detectors, and supply-voltage splitters. An equally important application involves signal-conditioning circuits for bridge transducers—circuits that require no reference voltage or instrumentation amplifier.

## Rectify signals without diodes

To keep costs low, battery-operated circuits for consumer applications should have a minimum component count. Fewer components also bestow the bonus of higher reliability. These considerations led to the half-wave-rectifier circuits of Fig 1. Neither circuit uses diodes. Because the op amp's input common-mode range extends beyond the supply rails, you can simply ground the noninverting terminal and thereby configure the amplifier as an inverter. You should also short the bias-adjust terminal (pin 5) to  $V^-$  to provide a maximum slew rate.

The amplifier behaves as a unity-gain inverter for negative inputs; positive inputs drive the output into saturation (Fig 1a). The NE5230's internal detectors prohibit the hard saturation that would occur in most op amps, however. Recovery from saturation is relatively fast. Operating from a 3V supply, the circuit can rectify

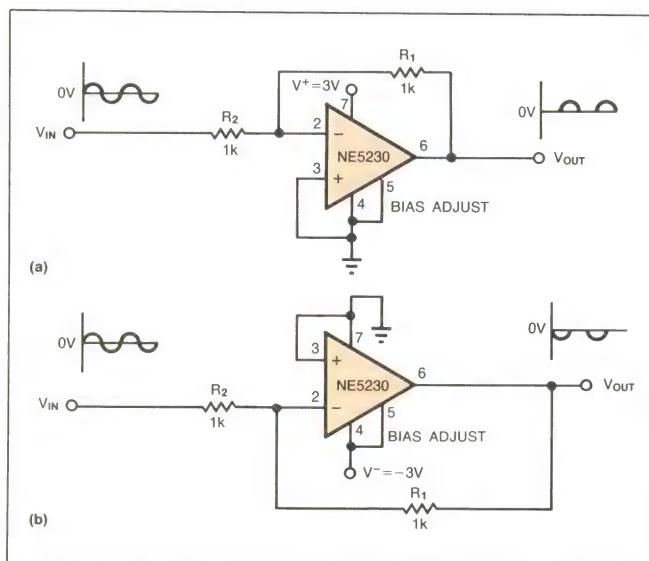
*Battery-operated circuits for consumer applications should have a minimum component count, and fewer components also bestow the bonus of higher reliability.*

signal amplitudes as high as  $\pm 2.85\text{V}$  at frequencies well above 10 kHz. If the input signal has a reference level between 0V and  $V^+$ , you can simply reference the amplifier's noninverting input to the same level. If required, resistors  $R_1$  and  $R_2$  can provide a gain other than unity.

To obtain a negative-polarity half-wave-rectified signal using a conventional op amp, you have to provide dual (bipolar) power supplies. The NE5230's rail-to-rail input range and near rail-to-rail output range, however, let you achieve this function using a single supply. Simply connect the supply's positive terminal and the amplifier's  $V^+$  terminal to ground, and connect the supply's negative terminal to the amplifier's  $V^-$  terminal (Fig 1b).

The amplifier's common-mode range lets you reference the input signal to the positive rail (ground) by tying the noninverting and  $V^+$  terminals together. (You can't do this with most op amps, and most op amps' output voltage must remain at least one  $V_{BE}$  voltage below the positive rail.) In short, you can use the amplifier with a single negative supply to condition the signal output from a variety of ground-referenced sensors. Again, if the input-signal reference is a voltage between 0V and  $V^-$  instead of ground, you should connect the amplifier's noninverting input to the same potential.

Overdriving most op amps (beyond the supply rail, for instance) saturates the input stage, causing a phase reversal within the amplifier that can reverse the feedback signal's polarity. Circuitry within the NE5230 prevents phase reversal for inputs as large as 2V beyond the supply rail. This feature allows the amplifiers of Fig



**Fig 1—These positive (a) and negative (b) half-wave-rectifier circuits accomplish their job without the use of diodes. The resistors give you the option of gains other than unity.**

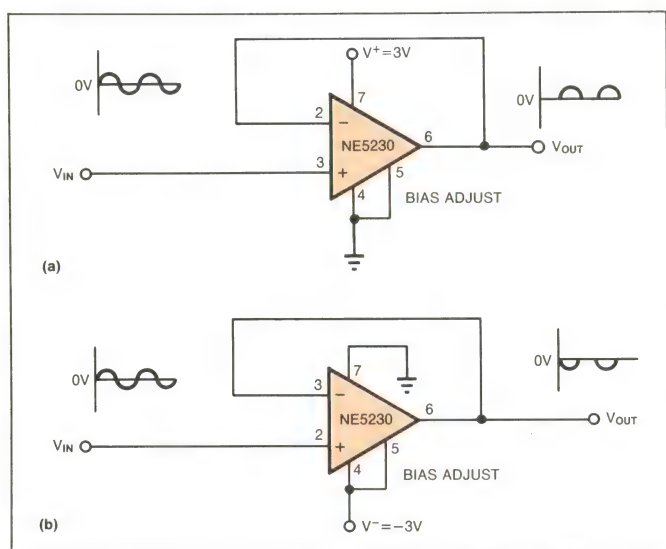
**TABLE 1—SALIENT SPECS FOR THE NE5230**  
( $V^+ = 1.8\text{V}$ ;  $V^- = \text{GND}$ )

	BIAS CURRENT*	$T_A = 25^\circ\text{C}$	$0^\circ\text{C} < T_A < 70^\circ\text{C}$
SINGLE/DUAL SUPPLY VOLTAGE	—	1.8 TO 15V OR $\pm 0.9$ TO $\pm 7.5\text{V}$	
SUPPLY CURRENT	LOW HIGH	110 $\mu\text{A}$ 600 $\mu\text{A}$	250 $\mu\text{A}$ MAX 800 $\mu\text{A}$ MAX
OUTPUT SWING	ANY	1.6V	1.4V MIN
$V_{OS}$	ANY	0.4 mV	4 mV MAX
$I_B$	LOW HIGH	20 nA 40 nA	150 nA MAX 200 nA MAX
$A_{VO}$	LOW HIGH	150V/mV 200V/mV	50V/mV MIN 100V/mV MIN
CMRR	ANY	95 dB	80 dB MIN
OUTPUT SOURCE CURRENT	HIGH	5 mA	4 mA (TYP) AT LOW BIAS
OUTPUT SINK CURRENT	HIGH	11 mA	5 mA (TYP) AT LOW BIAS
SLEW RATE	LOW HIGH	90V/mSEC 250V/mSEC	90V/mSEC 250V/mSEC
BANDWIDTH	LOW HIGH	250 kHz 600 kHz	—

\*NOTE: THE NE5230 OPERATES AT LOW BIAS CURRENT IF THE BIAS ADJUST PIN (PIN 5) IS LEFT OPEN. SHORTING THE NE5230'S PIN 5 TO  $V^-$  PROVIDES MAXIMUM BIAS CURRENT. CONNECTING A VARIABLE RESISTOR BETWEEN PIN 5 AND  $V^-$  LETS YOU ADJUST THE AMPLIFIER'S BIAS CURRENT AND HIGH-FREQUENCY CHARACTERISTICS.

2 to produce half-wave rectification without external components for input signals referenced to 0V.

In **Fig 2a**, the amplifier output follows the input signal above 0V and goes into negative saturation for inputs below 0V. (The output clamps near 0V for negative inputs.) The circuit as shown can rectify signals of  $\pm 2V$  at frequencies above 10 kHz. Inputs below  $-2V$  will cause internal phase reversal, however, allowing the output voltage to rise. You can prevent this



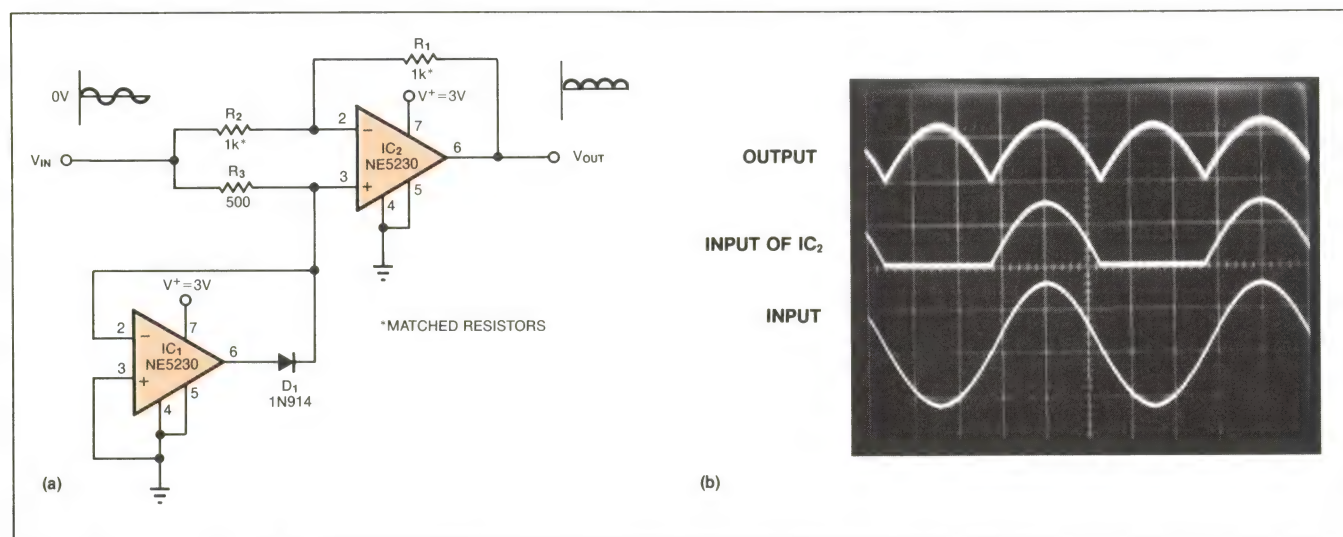
**Fig 2**—Requiring no external components, these op amp circuits perform positive (a) and negative (b) half-wave rectification for ground-referenced ac signals.

situation by adding a large resistor in series with the amplifier's input. To obtain a negative-polarity half-wave rectifier, simply reverse **Fig 2a**'s supply-voltage connections (**Fig 2b**). Again, this circuit can rectify 0V-referenced signal amplitudes to  $\pm 2V$  at frequencies above 10 kHz.

**Fig 3**'s circuit performs full-wave rectification using a single positive power supply. When a negative input voltage causes  $IC_1$  to clamp  $IC_2$ 's noninverting input to 0V,  $IC_1$  delivers current through  $D_1$  and  $R_3$  to the signal source.  $IC_2$  acts as an inverting amplifier for negative input signals. Positive input signals produce a differential voltage between the  $IC_1$  inputs and create reverse-bias across  $D_1$ , placing  $IC_1$ 's output in negative saturation. This condition removes the 0V clamp at  $IC_2$ 's inverting input by breaking  $IC_1$ 's feedback loop. Consequently,  $IC_2$  behaves as a follower during positive excursions of the input voltage.

Although  $D_1$  is reverse-biased, clamp diodes at  $IC_1$ 's inverting input turn on and draw current through  $R_3$ . Accordingly,  $R_3$ 's value should be 500 $\Omega$  or less to avoid a significant offset due to this parasitic current flow. ( $R_1$  and  $R_2$  can be large-valued resistors.) **Fig 3b** shows the circuit operating with a 5.7V p-p signal at 400 Hz. Similar to the way it rectified the half-wave circuits, the NE5230 performs negative full-wave rectification in **Fig 4** using a single negative power supply. The same precautions apply as for **Fig 3**.

You can also use the NE5230 to monitor a signal and to detect fault conditions in which the signal is shorted



**Fig 3**—This absolute-value circuit (a) achieves full-wave rectification by clamping  $IC_2$ 's noninverting input to 0V when  $V_{IN}$  is negative, and removing the clamp when  $V_{IN}$  is positive. Thus,  $IC_2$  alternates between an inverter and a follower every half cycle. The photo (b) shows circuit performance at 400 Hz for a 5.7V p-p input signal. The vertical scale is 2V/div, and the horizontal scale is 0.5 msec/div.

*Overdriving most op amps saturates the input stage, causing a phase reversal within the amplifier that can reverse the feedback signal's polarity.*

to either supply voltage. The window-detector circuit of Fig 5 must have the same supply voltage as that of the remote signal source. Power-supply currents through  $R_1$  and  $R_2$  create small offsets essential to the circuit's operation.

Both op amp outputs remain in positive saturation for  $V_{IN}$  values between approximately 0 and 3V, which keeps the LED off. If  $V_{IN}$  shorts to  $V^+$ , however,  $IC_1$  saturates negatively (at 0V), turning on the LED. Similarly,  $IC_2$  turns on the LED by saturating negatively when  $V_{IN}$  shorts to ground. As you can see, the op amp inputs' series resistors and clamp diodes limit the current drawn from the  $V_{IN}$  source.

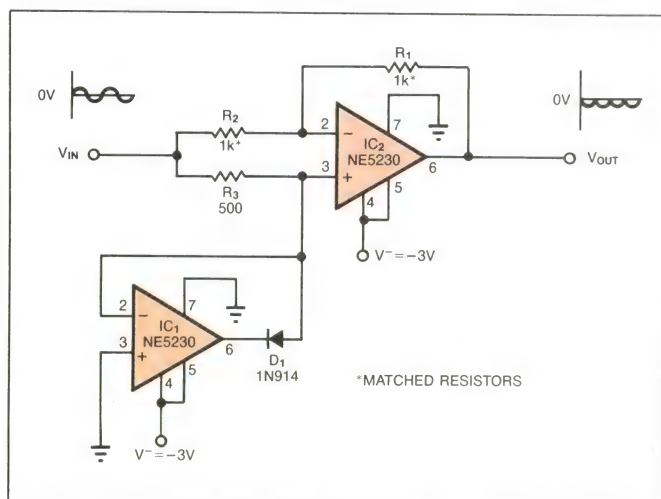
Normally, building a 2-limit temperature alarm requires a temperature sensor and two op amps. The NE5230 itself becomes a temperature sensor, however, if you make use of the PTAT (proportional to absolute temperature) voltage at pin 5. This voltage is independent of the supply voltage and measures 14 mV at 27 °C. What's more, it changes predictably at a rate of 46.667  $\mu V/^{\circ}C$ . For instance, at +85 and  $-15^{\circ}C$ , the pin 5 PTAT voltage is 16.7 and 12.04 mV, respectively.

The alarm circuit (Fig 6) uses these trip points to activate a buzzer when the ambient temperature moves outside of the  $-15$  to  $+85^{\circ}C$  window. The  $R_1/R_2$ -divider voltage sets the upper temperature limit and the  $R_3/R_4$ -divider voltage sets the lower one. When the ambient temperature exceeds  $85^{\circ}C$ ,  $IC_1$ 's inverting-input voltage is more positive than that at the noninverting input, and the resulting saturated output (0V) causes the buzzer to sound. Conversely,  $IC_2$ 's

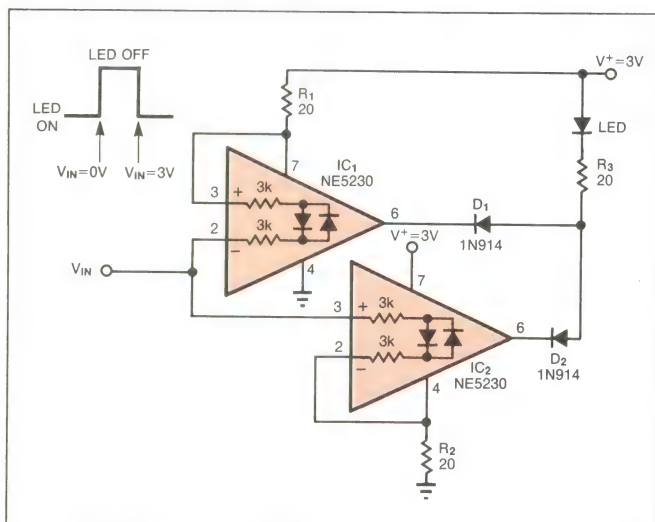
output sounds the buzzer when the ambient temperature drops below  $-15^{\circ}C$ , again by going into negative saturation.

The resistors that you use in the voltage dividers should have similar temperature coefficients to prevent a shift in threshold voltage as the temperature changes. On the other hand, the op amp's input-offset voltage ( $V_{OS}$ ) has a greater effect on the circuit's accuracy. Because  $V_{OS}$  is a significant percentage of the small PTAT voltage, you must set the temperature limits far apart to reduce error. The typical 400- $\mu V$   $V_{OS}$  and 5- $\mu V/^{\circ}C$   $V_{OS}$  drift can introduce an uncertainty of  $\pm 15^{\circ}C$  or more. Although Fig 6 isn't intended for precision applications, you can improve its accuracy by selecting NE5230s with low  $V_{OS}$ .

The battery-operated intrusion detector of Fig 7 illustrates another type of alarm circuit possible with the NE5230 op amp. Using an electret-microphone sensor, the circuit activates a buzzer when the ambient sound exceeds a user-specified threshold. Resistor  $R_3$  biases the microphone and capacitor  $C_1$  blocks the microphone's dc signal component.  $IC_1$  is connected as an inverting amplifier with adjustable gain. The amplifier can't respond to positive inputs because the  $V^-$  terminal is grounded, and without sound the amplifier's input and output are near 0V. The output drives an RS (reset-set) flip-flop formed by the cross-coupled CMOS Nor gates. Therefore, in the absence of sound the flip-flop's  $\bar{Q}$  output is high, and the buzzer is off.  $IC_2$ 's negligible standby current and the low quiescent cur-



**Fig 4**—This circuit (obtained by reversing the power-supply connections in Fig 3) performs negative full-wave rectification using a single supply voltage.

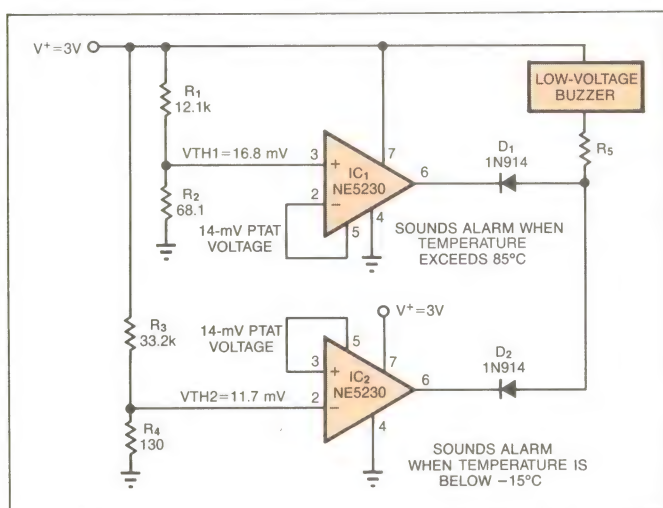


**Fig 5**—This window detector's rail-to-rail input range allows the circuit to detect faults in which the input signal becomes shorted to either rail.

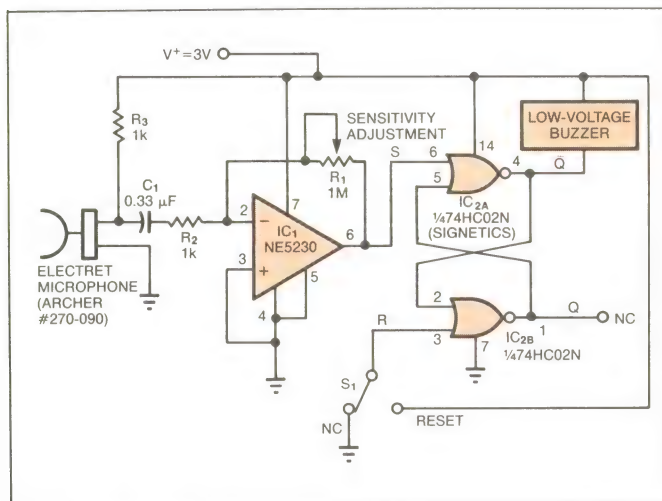
rent of the microphone and op amp ensure long battery life.

### Sound detector has adjustable threshold

Sound causes the microphone to produce an ac signal whose reference is ground on the other side of  $C_1$ . (The capacitor you choose should have low leakage current.) This signal's negative excursions produce positive excursions at the flip-flop's S input. If the amplifier's gain (set by  $R_1$ ) is sufficient, the signal at S will cross the gate's switching threshold and latch the  $\bar{Q}$  output low,



**Fig 6**—The op amp's bias-adjust pin (pin 5) is the PTAT (proportional to absolute temperature) voltage, which lets you use the amplifier as a temperature sensor. This circuit activates the buzzer when the temperature exceeds a user-specified limit.



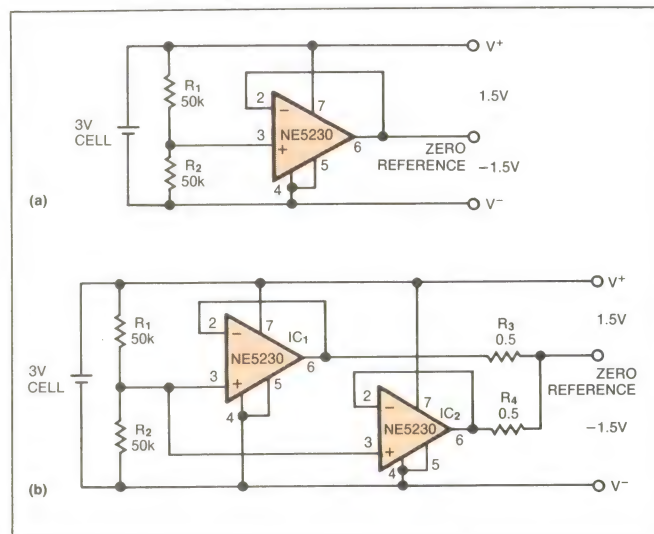
**Fig 7**—Ambient sound above a user-determined threshold activates this intrusion detector. Once triggered, the alarm will sound until you momentarily press the switch ( $S_1$ ).

activating the buzzer. The buzzer will remain on until you reset the latch by momentarily pressing  $S_1$ . Remember that high closed-loop gain settings will reduce the circuit's sensitivity to high-pitched sound by lowering the amplifier's  $-3$ -dB bandwidth. If you need more sensitivity, you can cascade two op amps and split the required gain between them.

Circuits that process ground-referenced signals often require dual power supplies, but dual-voltage battery supplies can increase a system's size and cost. You can avoid this extra hardware in some cases by converting a single 3V lithium-battery output into a  $\pm 1.5$ V output (Fig 8a). The  $R_1/R_2$  divider splits the 3V supply, and the op amp's 40-nA input-bias current offers a minimal load to the divider. The amplifier's output becomes the common terminal for all ground-referenced loads and signals.

The NE5230's low output impedance minimizes any offset voltage created by the connection of loads between the amplifier's output and  $V^-$  or  $V^+$ . Moreover, the dual voltages track in magnitude as the battery cell discharges—a feature useful in applications that must maintain a precise voltage null despite fluctuations in the supply voltages. The Fig 8a circuit sources and sinks 15 and 24 mA, respectively.

To obtain higher load currents, you can connect two NE5230s in parallel (Fig 8b). The difference in offset voltages ( $\Delta V_{OS}$ ) appears across  $R_3$  and  $R_4$ . The standby current in one op amp increases by  $\Delta V_{OS}/(R_3 + R_4)$ , but current in the other op amp decreases by the same



**Fig 8**—The circuit in (a) converts a 3V cell into a  $\pm 1.5$ V dual tracking supply. By connecting two amplifiers in parallel (b), you can nearly double the circuit's load-current capability.

*The op amp becomes a temperature sensor if you make use of the PTAT (proportional to absolute temperature) voltage at pin 5.*

amount, so the sum of the supply current through the two op amps remains constant.

Large load currents divide equally between the two op amps, and you would expect this circuit to provide twice the output current of Fig 8a, but the load-current capability is generally less because of mismatch in the op amp's output resistances and mismatch between  $R_3$  and  $R_4$ . The Fig 8b circuit sources and sinks 24 and 35 mA, respectively, when operating from a 3V supply.

Bridge transducers for precision applications usually

require an accurate low-drift voltage reference and a precision instrumentation amplifier (see box, "What you should know about bridge circuits"). The Fig 9 circuit, however, acquires and displays the bridge transducer's output without using a voltage reference or an instrumentation amplifier.

Op amp IC<sub>1</sub> buffers the fixed arm of the bridge and provides a reference potential for all ground-referred loads. Choosing this node as the reference potential converts the bridge's differential output signal to a

## What you should know about bridge circuits

A bridge circuit, often known as a Wheatstone bridge, consists of a pair of series-connected resistors connected in parallel with a similar pair of resistors (Fig A). Bridge circuits are widely found in precision-null applications because the differential voltage ( $V_1 - V_2$ ) across the bridge is 0V when the bridge is balanced.

What's more, this balanced condition is unaffected by voltage drops across line resistances or shifts in the reference voltage  $V_R$ . You can use such a balanced bridge to measure capacitance,

inductance, or its own frequency of excitation (when applied in place of  $V_R$ ).

A more common application for a bridge circuit is as a bridge transducer for converting physical parameters such as temperature or pressure into electrical signals. Normally, the resistance in one arm of the bridge varies with the measured parameter as resistances in the other three arms remain constant. This type of application usually includes a differential amplifier to amplify the bridge's differential output voltage.

The amplifier's output indicates any change in the measured parameter with respect to a reference level corresponding to the condition of a balanced bridge. You do need a fixed reference voltage; shifts in  $V_R$  will change the amplifier's output voltage unless the bridge happens to be balanced. The bridge's output signal usually consists of several millivolts riding on a much larger common-mode signal.

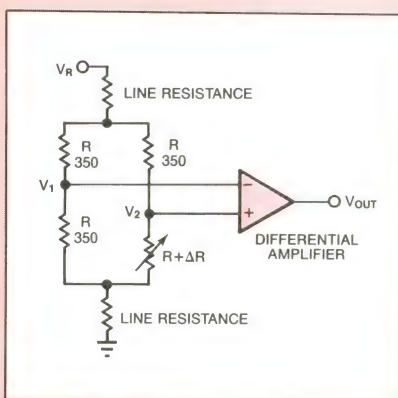
Accordingly, you should choose a bridge amplifier that minimizes inaccuracies through high common-mode rejection

(CMR), low input-offset voltage ( $V_{OS}$ ), and low  $V_{OS}$  drift with temperature. The amplifier should have high open-loop gain to ensure a linear transfer function and low input-bias current to avoid loading the bridge. An instrumentation amplifier meets all these requirements and is designed specifically for conditioning the output of bridge transducers.

Note that even an ideal bridge amplifier will have a nonlinear response because the bridge itself is inherently nonlinear. The following derivation shows why:

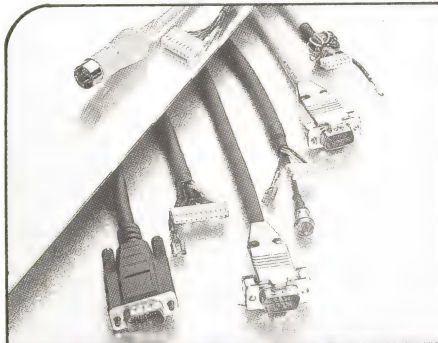
$$\begin{aligned} V_O &= A_{CL}(V_1 - V_2) \\ &= A_{CL} \left[ \frac{V_R}{2} - \frac{V_R(R + \Delta R)}{R + R + \Delta R} \right] \\ &= -\frac{A_{CL} V_R}{4} \left( \frac{\Delta R/R}{1 + \Delta R/2R} \right). \end{aligned}$$

$A_{CL}$  is the amplifier's closed-loop gain. The bridge's output signal is nonlinear because both the numerator and the denominator contain the transducer-deviation term  $\Delta V$ . The signal is approximately linear over a small range of amplitudes, however. Such signals are held to low amplitude for that reason.



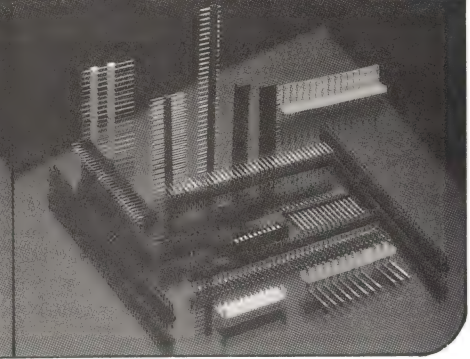
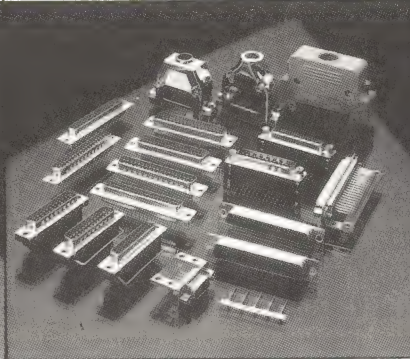
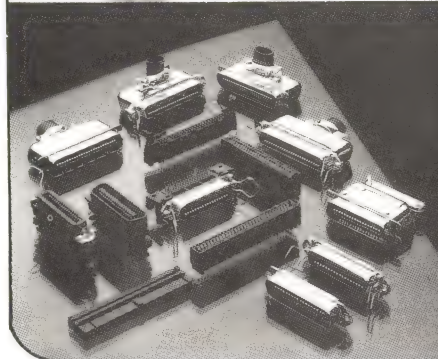
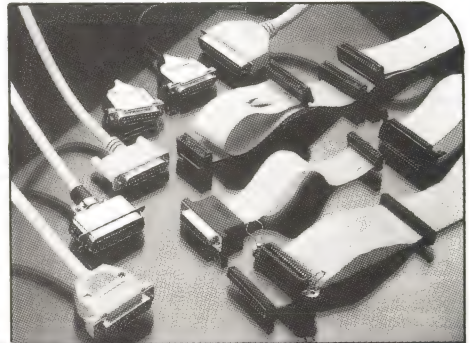
**Fig A**—In a conventional transducer bridge, the parameter of interest causes a variation ( $\Delta V$ ) in the bridge's output. The amplifier senses the resulting small differential signal and also rejects the bridge's relatively large common-mode voltage.

# Your Connectors Specialist



We supply a wide range of products to boost your sales in 1987, including PS/II signal cable Round Cable & Flat Cable Assemblies, D-Subconnectors, 57 Series Connectors, Modular Jacks, Gender Changers, Switching Power Supplies, Pin Headers, Terminal Strips, etc. Contact us right away for further information.

**OEM WANTED!**



**Manufacturer & Exporter**



**GREATLINK ELECTRONICS TAIWAN LTD.**

3/F., No. 16, Lane 54, Chung Cheng Rd. Hsin-Tien City, Taipei, Taiwan, R.O.C.

Tel: 886-2-917-9261

Tlx: 34559 GTLINK

Fax: 886-2-917-8064

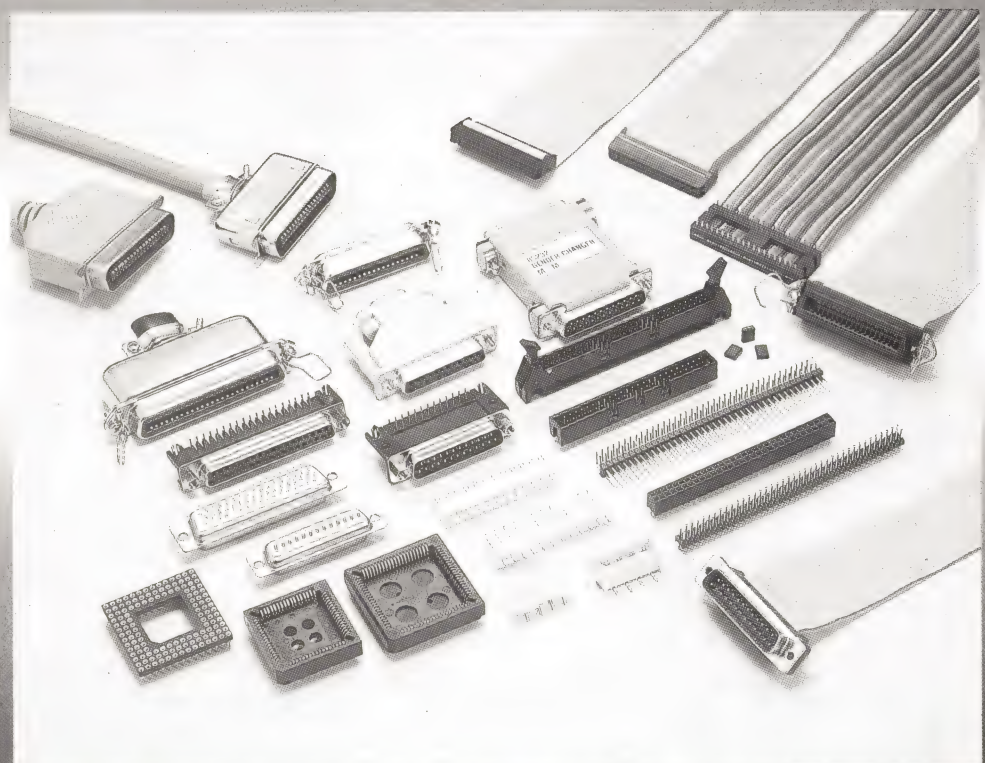
**CIRCLE NO 117**

# Our High Quality Connectors Are Made for Our Good Connection

Here's a full range of quality connectors to support your products and increase your profits OEM projects are most welcome. Send for details today!

**OEM & Agent Wanted!**

**CIRCLE NO 98**



**NS-Tech**

**NS-TECH CO., LTD.**

3/F., No. 2, Lane 34, Tung Shin St.

Nankang, Taipei, Taiwan, R.O.C.

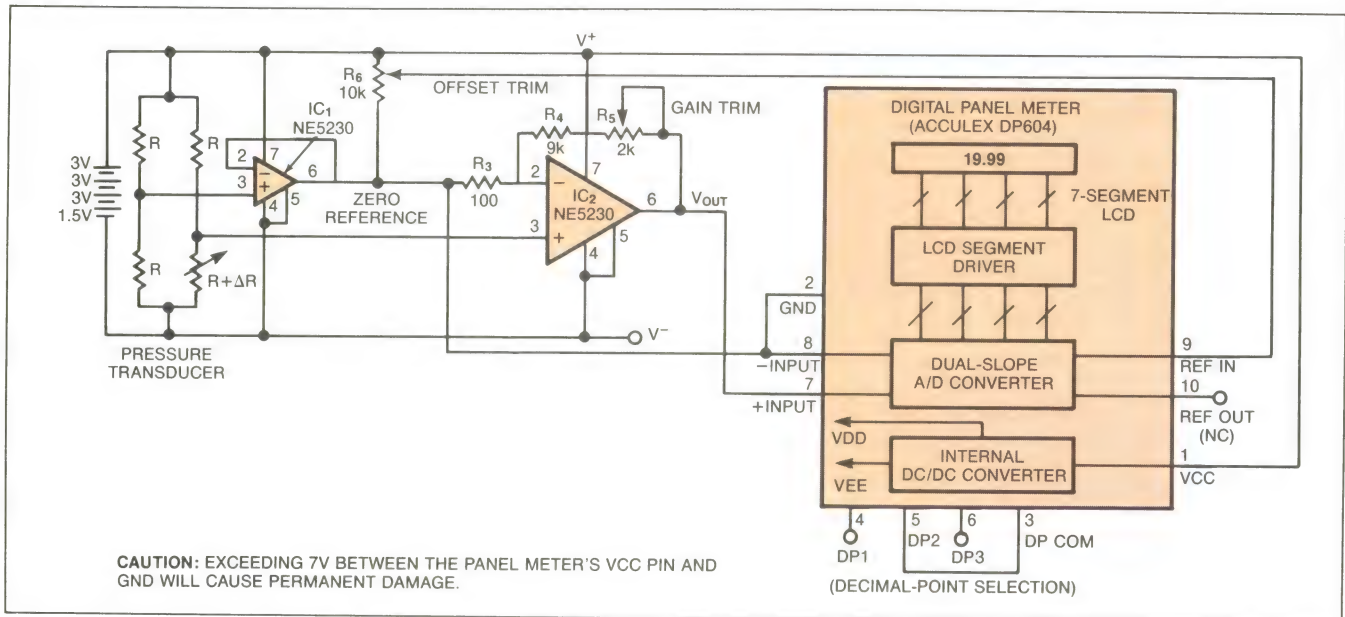
P.O. Box 5-43, Nankang, Taipei, Taiwan, R.O.C.

Tel: (02) 7623656 7695688 7620718

Fax: 886-2-7628202

Tlx: 12427 TOHO TRAD Attn: NS-TECH

*Bridge transducers for precision applications usually require an accurate low-drift voltage reference and a precision instrumentation amplifier.*



**Fig 9—***This bridge-transducer interface circuit conditions the bridge's output signal for ratiometric operation and eliminates the need for a reference voltage and an instrumentation amplifier.*

single-ended signal referred to ground. This reference remains halfway between  $V^+$  and  $V^-$  even if the battery discharges. The reference potential is thus a floating ground, often called an active guard.

Converting the bridge's differential signal to a ground-referred signal eliminates the bridge output's common-mode voltage, which also eliminates the need for common-mode rejection, usually obtained by adding an instrumentation amplifier. IC<sub>2</sub> amplifies the bridge's output signal, and  $R_5$  lets you adjust the circuit's full-scale output level.

The IC<sub>2</sub> output  $V_{OUT}$  will change as the batteries discharge, but the  $V_{OUT}/V^+$  ratio will remain fixed. This relationship lets you remove the effect of battery discharge by operating the panel meter's A/D converter in the ratiometric mode. Connect the wiper of  $R_6$  to the converter's reference input to ensure that the signal and reference remain in proportion as the supply voltage changes. Finally, note that IC<sub>2</sub> amplifies its own input-offset voltage. You should null this effect by first balancing the bridge, and then adjusting  $R_6$  for an all-zeros output at the panel meter.

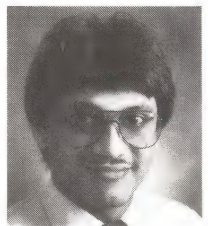
**EDN**

## References

1. Huijsing, Johan H, and Linebarger, Daniel, "Low-voltage operational amplifier with rail-to-rail input and output ranges," *IEEE Journal of Solid-State Circuits*, Vol SC-20, December 1985, pg 1144-1150.
2. Huijsing, Johan H, "Multistage amplifier with capacitive nesting for frequency compensation," US Patent Application Serial No 602.234, filed April 19, 1984.
3. Blauschild, Robert, "Differential amplifier with rail-to-rail capability," US Patent Application Serial No 525.181, filed August 23, 1983.

## Author's biography

*Zahid Rahim is a design engineer with Signetics Corp in Sunnyvale, CA, and is responsible for the design of data-conversion and -acquisition ICs. He is a member of the IEEE and enjoys playing tennis and collecting coins.*



## Acknowledgment

*The author would like to thank Johan Huijsing and Daniel Linebarger, designers of the NE5230, and Louie Burgyan, design manager and project leader.*

Article Interest Quotient (Circle One)  
High 491 Medium 492 Low 493

# Finally . . . PRECISION IN SURFACE MOUNT DEVICES

Yes, finally! Precision in a small package.

PMI's precision bipolar analog and CMOS converter product line is now offered in SMD. Write for our SMD brochure which lists the availability of 65 devices in various surface mount packages.

PMI's precision SMDs are available in commercial and industrial temperature ranges. The surface mount offerings include SO, SOL, LCC, and PLCC versions.

To get your SMD brochure, circle the reader service number or call . . . 1-800-843-1515.

You'll also receive a free copy of our new 1988 Data Book!

Precision Monolithics Inc.

A Bourns Company  
Santa Clara, California, USA  
408-727-9222

FRANCE: (1) 40 03 35 93; GERMANY: (0711) 22 93-0; BENELUX: (070) 87 54 04; SWITZERLAND: (042) 33 33 33;  
UNITED KINGDOM: (0276) 692 392; HONG KONG: (852) 570-2171; JAPAN: (03) 260-1411; ARGENTINA: (46) 5776/0628/0864/2214;  
AUSTRALIA: (02) 439-4655; AUSTRIA: (0222) 43 26 39; DENMARK: (02) 98 63 33; FINLAND: (90) 565 38 77; INDIA: 641 7902;  
ISRAEL: (23) 924 09 25; ITALY: (02) 569 57 46; KOREA: (02) 244-7492; NORWAY: (06) 83 20 00; SINGAPORE: (65) 339 331;  
SPAIN: (91) 405 42 13; SWEDEN: (08) 768 05 60; TAIWAN: (02) 752 2200; YUGOSLAVIA: (041) 42 37 46

CIRCLE NO 97



*The precision solution.*

# Cut your losses



## High current, low dropout regulators reduce power loss

Stop wasting power, space and weight. With our LT1083/84/85 positive adjustable regulator family, you'll easily achieve high current at low dropout voltage with precision performance. Low dropout voltage allows dramatic reductions in power dissipation, or increases headroom and operating flexibility. Cut heat sink sizes by 50% and enjoy lower system costs with our TO-247 and TO-220 packages.

All three regulators are pin-compatible with existing three-terminal adjustable devices. They are rated 7.5A, 5A and 3A, with a guaranteed dropout voltage of 1.5V at maximum output current. This makes them the lowest dropout regulators in their class.

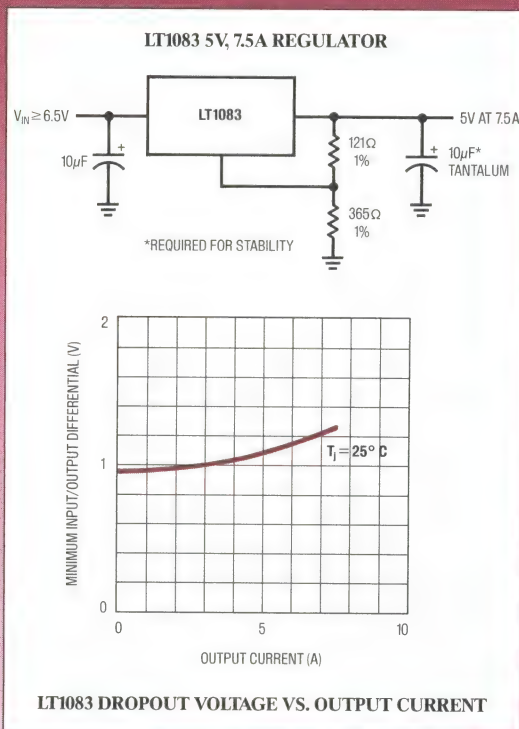
Short-circuit and safe area protection are included on the chips, and these regulators don't need protection diodes. Unlike most PNP low dropout regulators where 10% or more of input current flows to ground and is wasted, our regulators

are efficient with all quiescent current flowing into the load.

This regulator trio delivers a strong array of specifications. On-chip trimming adjusts reference voltage error to less than  $\pm 1\%$ . Line and load regulation are 0.015% and 0.1%, respectively. Current limit trimming minimizes stress on the power source, since maximum current is well controlled. For greater reliability, all units are subjected to 100% thermal limit burn-in.

Typical applications include high efficiency voltage regulators, constant current regulators, and post regulators for switching power supplies.

Cut your losses with our triple-threat power regulator family. LT1083/84 devices are packaged in TO-3 metal cans and TO-247 plastic. The LT1085 is in TO-3 and TO-220 plastic, and all are offered in MIL-STD-883 versions. Pricing begins at \$3.70 each, in quantities of 100. For literature contact: LINEAR TECHNOLOGY CORPORATION, 1630 McCarthy Blvd., Milpitas, CA 95035. 800-637-5545.



**LINEAR**  
TECHNOLOGY

TOUGH PRODUCTS  
FOR TOUGH APPLICATIONS.

CIRCLE NO 96

# DESIGN IDEAS

EDITED BY TARLTON FLEMING

## Baseline restorer is voltage-programmable

Peter Henry  
Precision Monolithics Inc, Santa Clara, CA

The Fig 1 circuit is a nonlinear, highpass filter that acts as an active baseline restorer (Fig 2). Baseline restoration improves the signal-to-noise ratio for pulse or ac measurements by counteracting the dc errors caused by amplifier drift and electromagnetic pickup. The circuit is particularly useful for signals derived from a high-impedance source such as the human body.

Unlike standard frequency-domain filters, this one acts on the slow rate rather than the frequency of the input signal. At  $V_{OUT}$ , the circuit restores the base level of input-signal pulses to an arbitrary level set by  $V_{REF}$ . You set the filter's slew-rate cutoff by adjusting  $V_{PROGRAM}$ , which in turn sets the currents  $I_1$  and  $I_2$ . (In applications such as analog adaptive filtering, you can set  $V_{PROGRAM}$  using a voltage-output D/A converter, or you can remove  $R_{PROGRAM}$  and set the currents using a current-output D/A converter.)

To understand the circuit operation, first note the action of the transistor current mirrors: Collector current in  $Q_2$  ( $I_1$ ) mirrors the collector current in  $Q_1$ , and the transistors  $Q_5$  and  $Q_6$  mirror this current again. Transistors  $Q_3$  and  $Q_4$  each mirror the  $I_1$  current as well, producing the current  $I_2 = 2I_1$ . This  $2\times$  relationship assures symmetric operation, in which the restoration rates are equal for positive and negative excursions from the baseline.

Assume the capacitor  $C$  has charged to the input signal's baseline voltage. If the baseline level of  $V_{OUT}$  attempts to rise, the  $IC_2$  output swings low, decreasing the current through  $D_1$ . This action causes a flow of current from capacitor  $C$  and thus restores equilibrium by lowering the voltage on  $C$ . Conversely, a tendency for the baseline to fall causes charge to flow onto the capacitor.

The  $IC_2$  op amp must have a high slew rate to ensure that the restoration circuitry keeps up with the pulses. The rate of restoration depends on the current available ( $I_1$ ) to charge  $C$ . Using  $V_{PROGRAM}$ , you can set this current to any value between a few nanoamps and a few milliamps. Higher current lets the circuit reject higher slew rates.

EDN

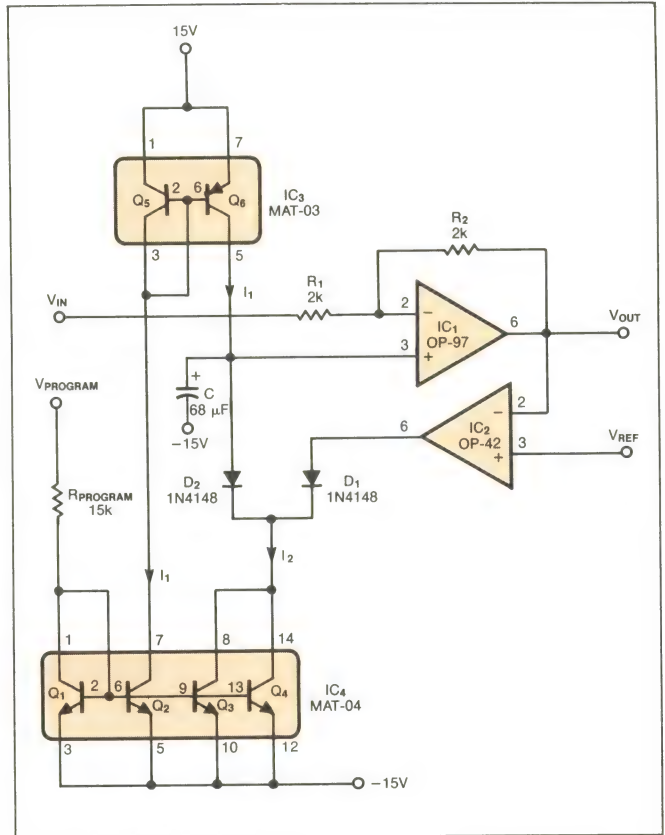


Fig 1—This circuit forces the bases of pulses in  $V_{IN}$  to the arbitrary level  $V_{REF}$ , and it rejects pulses on the basis of slew rate according to the voltage  $V_{PROGRAM}$ .

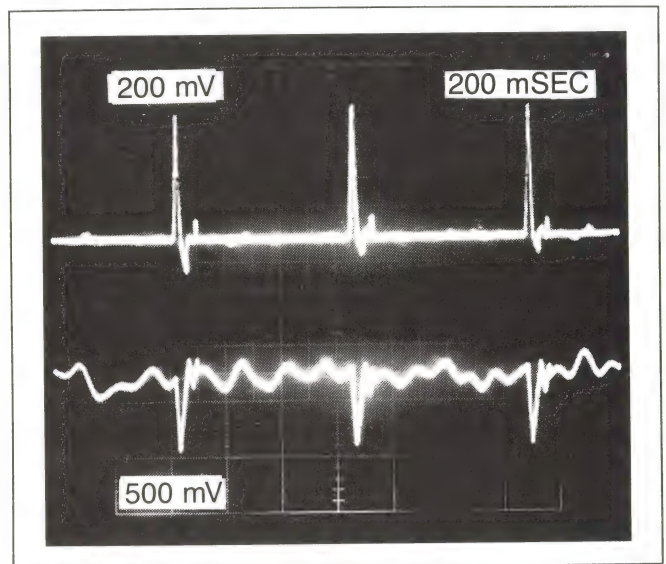


Fig 2—These waveforms show that the Fig 1 circuit's output (upper trace) inverts  $V_{IN}$  (lower trace) while filtering and restoring the signal's baseline voltage level.

To Vote For This Design, Circle No 749

## Program designs T flip-flop state machines

David Van Ess

Rothenbuhler Engineering, Sedro Woolley, WA

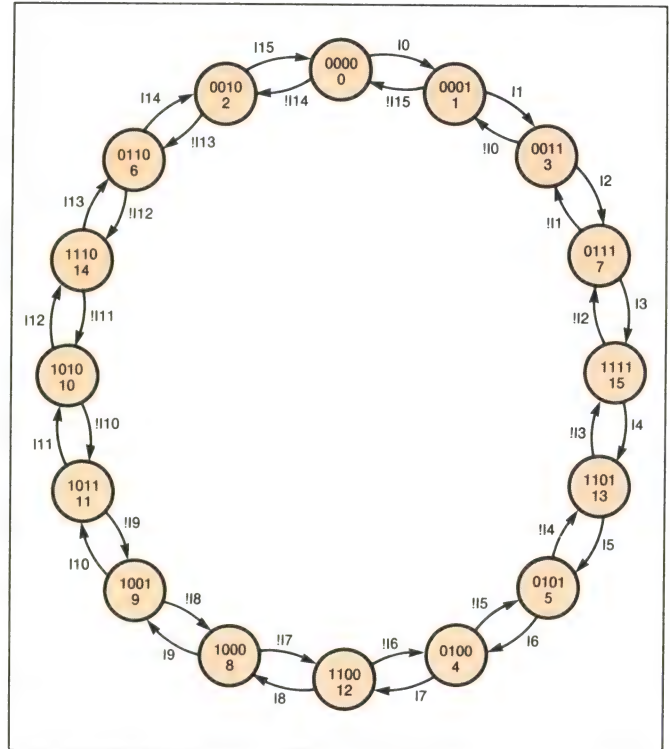
The **Listing 1** program generates Boolean equations describing a state machine based on T flip-flops. Such a state machine requires product terms for only those bits that change with the transition from one state to another, making it suitable for implementation in a PLD, which has a limited number of product terms available. Several of the newer PLDs let you configure their output registers as T flip-flops (a T flip-flop toggles when its single input is high).

To design a state machine, first draw a state diagram. (The example in **Fig 1** has 16 states and requires four flip-flops.) Assign each state a value that represents a specific and unique combination of the register's outputs. Note that each state differs by one bit from the states on either side. For any design, the unused states should be fed back into the state diagram. An undefined state feeds zeroes to all the flip-flops, which locks up the hardware by preventing the flip-flops from toggling.

Next, enter the state data in an input file (**Listing 2**). To run the program, enter

```
state <example.in> example.out
```

The output (**Listing 3**) contains unminimized Boolean expressions; you can minimize them using logic-description software such as Abel or CUPL. This state ma-



**Fig 1**—This diagram describes a state machine based on four T flip-flops. The state machine has 16 states; none are unused.

chine will just fit into an Intel 5C060 or an Altera EP600 PLD.

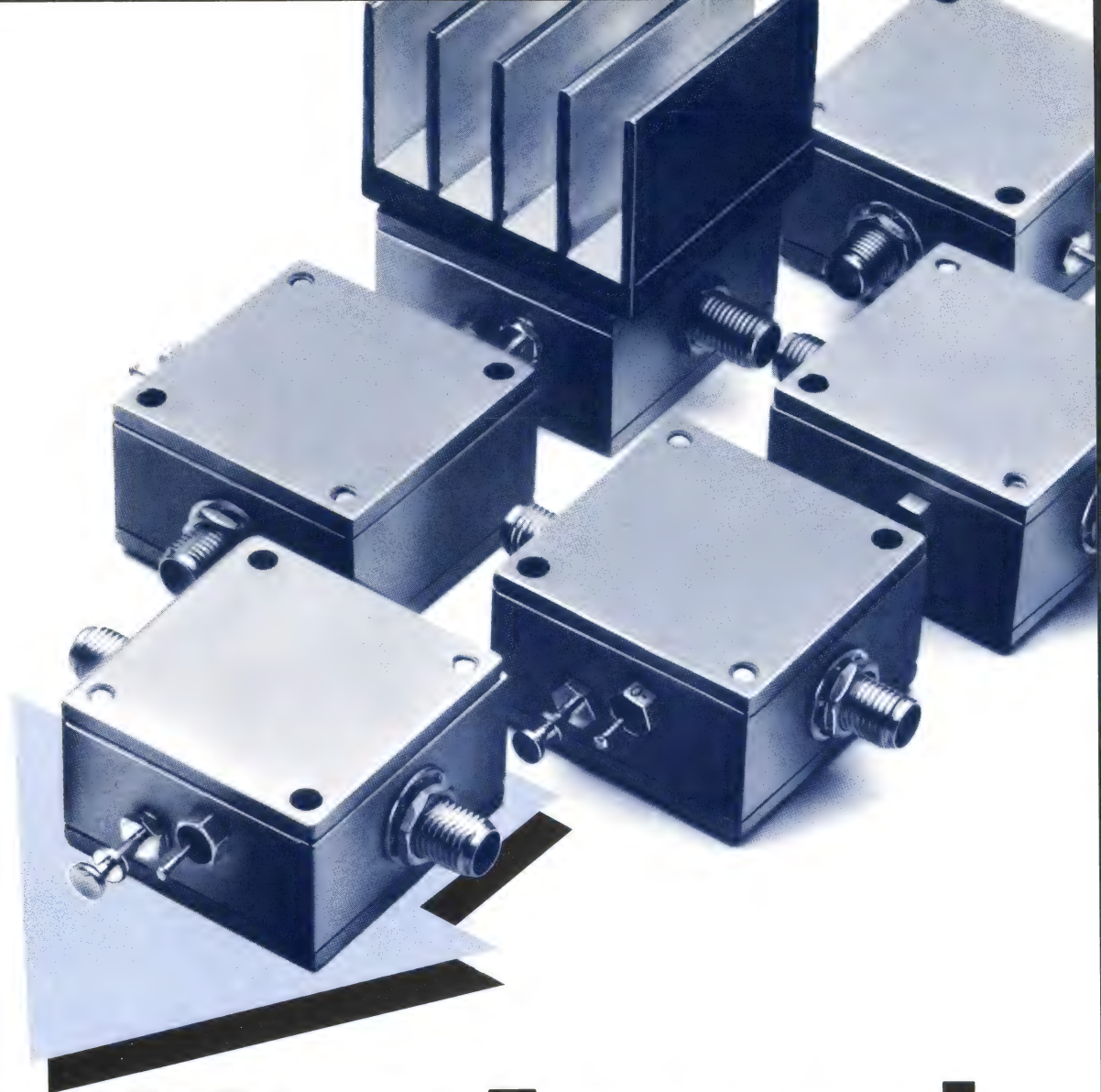
The **Listing 1** program was compiled on an IBM

### LISTING 1—T FILP-FLOP STATE-MACHINE PROGRAM

This program generates logic equations for state machines with up to 8 "T" registers. The output is the equation to implement it. Input is stdin, output is stdout, error is stderr. Below is an example of a 2 bit up/down counter. The first character of input must be that number of registers. All tabs and spaces are ignored. Upper, lower, or mixed case allowed.

```
2"very first character MUST be the # of registers
"this is a comment
at 0
on[ up ]1
on[!up ]3
at1
on[ up ]2 "this comment must have a white space before it
on[!up ]0
AT2
ON[ up ]3
ON[!up ]1 "this comment must have a white space before it
At 3
on [ up ] 0
on[!up ]2
End
*/
```

Listing continued on pg 194



# Amplifier Arsenal

50KHz—2000MHz, Low Noise 100mW output Gain Controlled from **\$69.95**

Our ZFL-2000 miniature wideband amplifier hit a bulls-eye when we introduced it last year. Now we've added more models to offer you a competitive edge in the continuing battle for systems improvement.

The ZFL-2000, flat from 10 to 2000MHz, delivers +17dBm output and is priced at only \$219.

Need more output? Our ZFL-1000H, flat from 10 to 1000MHz, delivers +20dBm output.

Is low noise a critical factor? Our ZFL-500LN and 1000LN boast a 2.9dB NF.

Variable gain important? Our ZFL-1000G, flat from 10 to 1000MHz, delivers +3dBm output with 30dB gain control while maintaining constant input/output impedance.

Searching for a high-quality, low-cost amplifier? Our ZFL-500 flat from 50KHz to 500MHz, delivers +10dBm output for the unbelievable low price of only \$69.95. Need to go higher in frequency? Consider the ZFL-750, from 0.2 to 750MHz, for only \$74.95. Or the \$79.95 ZFL-1000, spanning 0.1 to 1000 MHz.

One week delivery...one year guarantee.

## SPECIFICATIONS

MODEL	FREQUENCY MHz	GAIN, dB (min.)	MAX. POWER OUTPUT dBm(typ)	NF dB(typ)	PRICE \$	
					Ea.	Qty.
ZFL-500	0.05-500	20	+9	5.3	69.95	1-24
ZFL-500LN	0.1-500	24	+5	2.9	79.95	1-24
ZFL-750	0.2-750	18	+9	6.0	74.95	1-24
ZFL-1000	0.1-1000	17	+9	6.0	79.95	1-24
ZFL-1000G*	10-1000	17	+3	12.0	199.00	1-9
ZFL-1000H	10-1000	28	+20	5.0	219.00	1-9
ZFL-1000LN	0.1-1000	20	+3	2.9	89.95	1-24
ZFL-2000	10-2000	20	+17**	7.0	219.00	1-9

\* 30dB gain control

\*\*+15dBm below 1000MHz

finding new ways ...  
setting higher standards

**Mini-Circuits**

A Division of Scientific Components Corporation

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500

Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156

C101 REV.C

# DESIGN IDEAS

## LISTING 1—T FILP-FLOP STATE-MACHINE PROGRAM *(Continued)*

```
#include <stdio.h>
#include <ctype.h>
char *L_pnt[ 8 ], *R_pnt[ 8 ]; /*Heep storage of generated equations*/
char Term[ 33 ], *T_pnt; /* the logic term for "at" */
char Condition[81], *C_pnt; /* condition information for "on" */
int Reg_num; /* number of flipflops */

main( ){
    int at_val, on_val, c, x;
    char *malloc(), *append();
    void cal_term(), generate();
    Term[32] = '\0';
    Reg_num = getchar() - '0'; /* first character is the number of registers*/
    for( x = 0 ; x < Reg_num ; x ++ ){
        L_pnt[ x ] = R_pnt[ x ] = malloc( 4096 );
        if ( L_pnt[ x ] == NULL ) {
            fprintf( stderr, "ERROR: not enough memory available\n" );
            exit( 1 );
        }
    }
    while(1){
        switch( c = getchar() ){
            case '"': /* comment line */
                while( (c = getchar()) != '\n' );
                break;
            case 'a': /* at stuff */
            case 'A':
                while( isdigit(c = getchar()) == 0 ); /*remove white space */
                at_val = c - '0';
                while( isdigit(c = getchar())) at_val = 10 * at_val + c - '0';
                cal_term( at_val );
                break;
            case 'o': /* on stuff */
            case 'O':
                C_pnt = Condition;
                *C_pnt++ = '[';
                while( (c=getchar()) != '[' );
                do( *C_pnt++ = (char)(c = getchar())); } while( c != ']' );
                if( Condition[1] == ']' ) C_pnt = Condition;
                *C_pnt = '\0';
                while( isdigit(c = getchar()) == 0 ); /*remove white space */
                on_val = c - '0';
                while( isdigit(c = getchar())) on_val = 10 * on_val + c - '0';
                generate( at_val ^ on_val );
                break;
            case 'e': /* end stuff */
            case 'E':
                for( x = 0 ; x < Reg_num; x ++ ){
                    printf("Q%c.t := ", 'a' + x );
                    if( L_pnt[ x ] == R_pnt[ x ] ){
                        printf( "0\n\n" );
                    }
                    else{
                        *R_pnt[x] = '\0';
                        printf( "%s\n", L_pnt[x] );
                    }
                }
                exit(0);
            case ' ': /* leading white space */
            case '\t':
            case '\n':
                break;
            default :
                fprintf( stderr, "ERROR:Something is wrong with your input\n" );
                exit( 1 );
        }
    }
}

void cal_term( state ) /* generate the boolean expression for new "at"*/
int state;{
    int x;
    T_pnt = &Term[32];
    for( x = 0 ; x < Reg_num ; x ++, state >>= 1 ){
        *--T_pnt = ' ';
        *--T_pnt = 'a' + x;
        *--T_pnt = 'Q';
        *--T_pnt = ( state % 2 ) ? ' ' : '!';
    }
}
```

*Listing continued on pg 196*



# The highest performance and highest integration, ever. Together on a single 16-bit chip.

The Z280™ gives you a more powerful CPU and higher performance peripherals than you've ever seen on a 16-bit chip. Think of it as a complete microsystem on a chip.

## Unmatched performance...

Start with the most powerful 16-bit engine available, add on-board Cache, MMU and Burst Mode memory support — and you'll begin to understand the Z280's power and potential.

## ...powerful on-board peripherals...

Imagine the savings in cost and board size when you have peripherals like 4 DMA channels that'll give you transfers at 6.6 Mbytes/sec, and a full-duplex UART.

... and the glue to tie it all together.

With a DRAM Controller to support up to 1 Mbit DRAMs and

Programmable Wait State Logic — on board — you're really looking at significant glue reduction.

## Z280: Truly a microsystem.

The Z280 gives you a lot more performance. In a lot less board space. All off the shelf and backed by Zilog's proven quality and reliability. Plus, it's binary code-compatible with the Z80\*, and priced to rival 8-bit chips. And all the development support tools you need are available from industry leaders. Contact your local Zilog sales office or your authorized distributor today. Seeing is believing. Zilog, Inc., 210 Hacienda Ave., Campbell, CA 95008 (408) 370-8000.

	Z280™	80186	68070
Package	68-pin PLCC/CMOS	68-pin LCC/NMOS	84-pin PLCC/CHMOS
Typical Power	375 mW	2 W	800 mW (est)
Speed	10-25 MHz	8-12.5 MHz	10 MHz
Memory Support	16 Mb Physical Paged	1 Mb Physical Segmented	16 Mb Physical 8 or 128 Segments
16-bit Registers	12 General	8 General	15 Dedicated
Instruction Pre-fetch	256-Byte Assoc. Cache; Burst Mode	6-Byte Queue	None
Multiprocessor Support	Local or Global	Local only	Local only
Wait Logic	Programmable	Programmable	Hardwire
DMA	4 Channels, 6.6 Mb/s @ 10 MHz	2 Channels 2 Mb/s @ 8 MHz	2 Channels, 3.2 Mb/s @ 10 MHz
Counter/Timers	3 16-bit	3 16-bit	2 16-bit
Serial I/O	1 Full-Duplex UART	None	1 Full-Duplex UART
DRAM Controller	10-bit Refresh	None	None
Price (100)	\$33	\$43	\$50

## The choice is clear.

## Right product. Right price. Right away.

**ZILOG SALES OFFICES:** CA (408) 370-8120, (714) 432-9971, (818) 707-2160, CO (303) 494-2905, FL (813) 585-2533, GA (404) 923-8500, IL (312) 885-8080, MA (617) 273-4222, MN (612) 831-7611, NJ (201) 288-3737, (609) 778-8070, OH (216) 447-1480, TX (214) 231-9090, CANADA Toronto (416) 673-0634, ENGLAND Maidenhead (44) (628) 781227, W. GERMANY Munich (49) (89) 612-6046, JAPAN Tokyo (81) (3) 587-0528, HONG KONG Kowloon (852) (3) 723-8979, R.O.C.: Taiwan (886) (2) 731-2420, U.S. AND CANADA DISTRIBUTORS: Anthem Electric, Bell Indus., Graham Elec., Hall-Mark Elec., JAN Devices Inc., Lionex Corp., Schweber Elec., Western Microtech., CANADA Future Elec., SEMAD.

**Zilog**  
an affiliate of  
**EXON Corporation**

# DESIGN IDEAS

## LISTING 1—T FILP-FLOP STATE-MACHINE PROGRAM (Continued)

```

}
void generate( diff ) /* generate the logic for this "on" statement */
int diff;{
    int x ;
    for( x = 0 ; x < Reg_num ; x ++, diff >= 1 ){
        if(diff % 2 ){
            if(L_pnt[x] != R_pnt[x]) R_pnt[x] = append( R_pnt[x], "      + " );
            R_pnt[x] = append( R_pnt[x], T_pnt );
            R_pnt[x] = append( R_pnt[x], Condition );
            R_pnt[x] = append( R_pnt[x], "\n" );
        }
    }
}
char *append( old_string, add_string ) /* append one string to another */
char *old_string, *add_string;{
    while ( *add_string ) *old_string++ = *add_string++;
    return( old_string );
}

```

## LISTING 2—INPUT FOR LISTING 1

" This state machine has 16 used states and 0 unused states.

```

at 0
    on [ I0 ] 1
    on [!I14] 2
at 1
    on [ I1 ] 3
    on [!I15] 0
at 2
    on [ I15] 0
    on [!I13] 6
at 3
    on [ I2 ] 7
    on [!I0 ] 1
at 4
    on [ I7 ] 12
    on [!I5 ] 5
at5
    on [ I6 ] 4
    on [!I4 ] 13
at6
    on [ I14] 2
    on [!I12] 14
at7
    on [ I3 ] 15
    on [!I1 ] 3
At8
    on [ I9 ] 19
    on [!I7 ] 12
At9
    on [ I10] 11
    on [!I8 ] 8
At10
    on [ I12] 14
    on [!I10] 11
At11
    on [ I11] 10
    on [!I9 ] 9
At12
    on [ I8 ] 8
    on [!I6 ] 4
at13
    on [ I5 ] 5
    on [!I3 ] 15
at14
    on [ I13] 6
    on [!I11] 10
at15
    on [ I4 ] 13
    on [!I2 ] 7

```

## LISTING 3—OUTPUT FROM LISTING 1

```

Qa.t := !Qd !Qc !Qb !Qa [ I0 ]
      + !Qd !Qc !Qb !Qa [!I15]
      + !Qd !Qc !Qb !Qa [ I15 ]
      + !Qd !Qc !Qb !Qa [ I6 ]
      + !Qd !Qc !Qb !Qa [ I9 ]
      + !Qd !Qc !Qb !Qa [!I8 ]
      + !Qd !Qc !Qb !Qa [!I10]
      + !Qd !Qc !Qb !Qa [ I11]

Qb.t := !Qd !Qc !Qb !Qa [!I14]
      + !Qd !Qc !Qb !Qa [ I1 ]
      + !Qd !Qc !Qb !Qa [ I15]
      + !Qd !Qc !Qb !Qa [!I0 ]
      + !Qd !Qc !Qb !Qa [ I10]
      + !Qd !Qc !Qb !Qa [!I9 ]
      + !Qd !Qc !Qb !Qa [!I3 ]
      + !Qd !Qc !Qb !Qa [ I4 ]

Qc.t := !Qd !Qc !Qb !Qa [!I13]
      + !Qd !Qc !Qb !Qa [ I2 ]
      + !Qd !Qc !Qb !Qa [ I14]
      + !Qd !Qc !Qb !Qa [!I1 ]
      + !Qd !Qc !Qb !Qa [!I7 ]
      + !Qd !Qc !Qb !Qa [ I12]
      + !Qd !Qc !Qb !Qa [ I8 ]
      + !Qd !Qc !Qb !Qa [!I11]

Qd.t := !Qd !Qc !Qb !Qa [ I7 ]
      + !Qd !Qc !Qb !Qa [!I4 ]
      + !Qd !Qc !Qb !Qa [!I12]
      + !Qd !Qc !Qb !Qa [ I3 ]
      + !Qd !Qc !Qb !Qa [!I6 ]
      + !Qd !Qc !Qb !Qa [ I5 ]
      + !Qd !Qc !Qb !Qa [ I13]
      + !Qd !Qc !Qb !Qa [!I2 ]

```

PC/AT computer using a Datalight C package, but the program should compile on most C packages. This program could be augmented with a preprocessor that would do syntax checking, look for out-of-range state values, and pinpoint input errors. Moreover, such a preprocessor should allow string substitution and the use of macros, so you could refer to the states by a name instead of their assigned value.

**EDN**

To Vote For This Design, Circle No 750

# Aeroflex announces the new math for MIL-STD-1553 design engineers.

## In which three goes into one just once.

1.

Low power dual redundant transceivers

2.

Dual decoder, encoder and protocol processor for Remote Terminal, Bus Controller and Bus Monitor

3.

Dual port RAM with 8K words of memory and full memory management

You are looking at the most powerful, flexible and unique MIL-STD-1553B interface currently available. Bar none.

Now, in one 2 x 3.1" package, this new ARX 2427 Universal Bus Interface Unit (UBIU) combines all the functions it takes three competitive hybrids to perform. Fact is, of all hybrids today, only the ARX 2427 reduces interface and hardware time to absolute zero.

The powerful ARX 2427 contains a dual port RAM that's double-sided and double-buffered to eliminate contention problems and wait states. Data can be mapped into RAM blocks by subaddress or alternately stacked. Memory is accessed for read and write using address lines and a select line, treated as subsystem memory. The host system is therefore freed from critical

timed response to Bus traffic and communication overhead is kept to a bare minimum. The unit also includes extensive error checking, which eliminates handling bad data. Fault monitoring plus many other features make the ARX 2427 clearly the most useful of 1553 interfaces.

So forget complex interconnect schemes. Forget special glue logic circuitry design

for subsystem compatibility. Forget using up valuable PC board real estate. The ARX 2427 is the UBIU to remember when you want to solve your 1553 problems—once—and for all.

For additional information call toll-free: 1-800-THE-1553 or TWX 510-224-6417. Or write Aeroflex Laboratories Inc., Microelectronics Division, 35 South Service Road, Plainview, NY 11803.



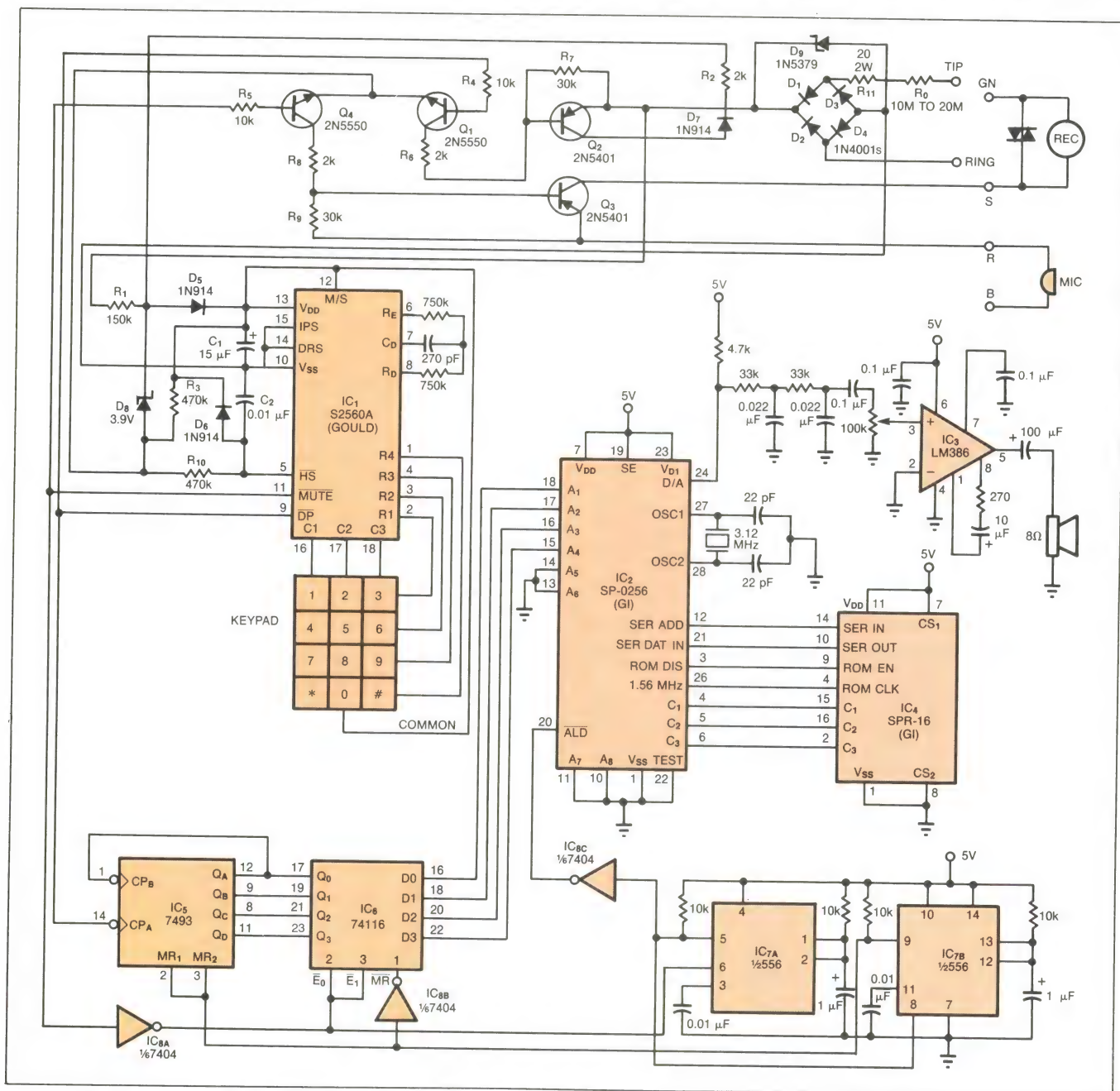
## Circuit vocalizes dialed phone numbers

V Lakshminarayanan  
Sneha Corp, Bangalore, India

A touch-tone telephone that includes the circuit of **Fig 1** produces a spoken report as you depress each key. By vocalizing the numbers and symbols of its keypad, the phone provides an audible confirmation that is useful to

the blind. The connections between circuit and telephone are in the figure's upper right corner.

The serial-interface, 2k-byte×8-bit ROM ( $IC_4$ ) stores programmed sequences of instructions that are executed by the speech-processor chip  $IC_2$  (manufactured by General Instrument Corp and available through Radio Shack). The applications brochure for  $IC_2$  con-



**Fig 1**—For each key you depress on a telephone keyboard, this circuit vocalizes the corresponding number or symbol.

# Now you can get speed, accuracy, and output drive in a single op amp ...OPA602.

## Speed

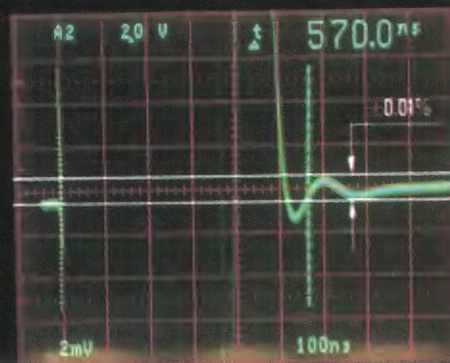
- 6.4MHz bandwidth
- $35\text{V}/\mu\text{s}$  slew rate
- $1\mu\text{s}$  settling (0.01%)
- Unity-gain stable

## Accuracy

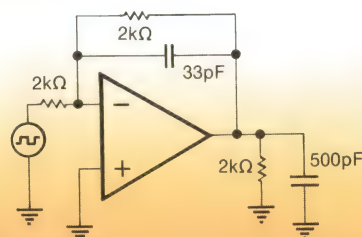
- $\pm 250\mu\text{V}$  offset max
- $2\mu\text{V}/^\circ\text{C}$  drift max
- $\pm 1\text{pA}$  bias current max

## Output Drive

- $\pm 20\text{mA}$  output
- $C_L = 1500\text{pF}$



Output Settling Time



Our new OPA602 gives you three amps in one, so you won't have to compromise on critical design parameters. It's fast, accurate, and handles tricky capacitive loads with no problems. Try it for your pulse and data conversion applications.

**Difet**® construction minimizes bias current and noise, so it's a good candidate for precision instrumentation and optoelectronics, too.

### Low cost, delivery off the shelf

Get all the details on the uncompromising new OPA602 from your sales engineer, or contact Applications Engineering, 602/746-1111. Burr-Brown Corp., P.O. Box 11400, Tucson, AZ 85734.

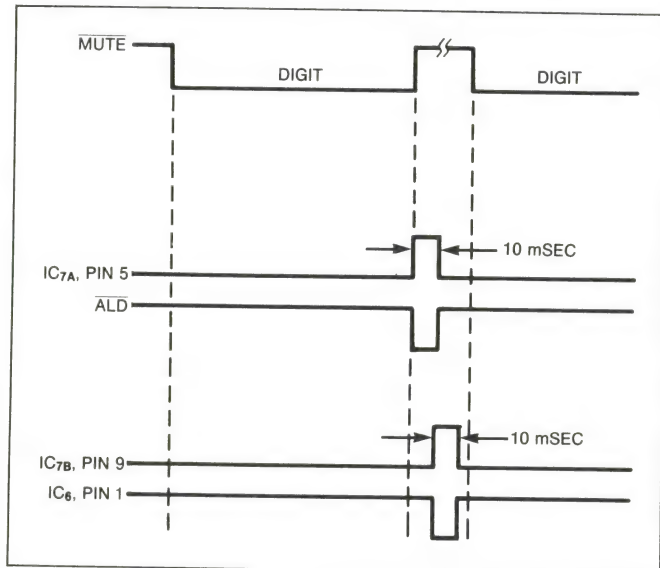
**Difet**® Burr-Brown Corp.  
\*U.S. prices only.

**BURR-BROWN®**  
**BB**

# DESIGN IDEAS

tains directions for composing the necessary instruction sequences.

When you depress a key, the tone-dialer chip IC<sub>1</sub>



**Fig 2**—These timing waveforms for the circuit in Fig 1 show the relationship between the MUTE signal and the reset and latch-enable pulses.

issues the corresponding number of pulses at its  $\overline{DP}$  output. Counter IC<sub>5</sub> totals the pulses, and IC<sub>6</sub> latches the resulting 4-bit digital word. This word, converted to serial format by IC<sub>2</sub>, becomes an address that selects a block of memory within IC<sub>4</sub>.

IC<sub>1</sub>'s MUTE output (which normally mutes the telephone receiver during dial pulsing) goes high during the pause interval between digits (Fig 2). Inverter IC<sub>8A</sub> inverts this signal, and the resulting negative edge triggers the IC<sub>7A</sub> timer (configured as a monostable multivibrator), which produces a 10-msec pulse at pin 5. This pulse latches the 4-bit address within IC<sub>2</sub> by driving IC<sub>2</sub>'s ALD input low. The pulse also triggers IC<sub>7B</sub> to produce another 10-msec pulse, which resets the IC<sub>5</sub> counter and the IC<sub>6</sub> latch.

Meanwhile, a microcontroller within IC<sub>2</sub> controls data flow from IC<sub>4</sub> and uses the data to create a pulse-width-modulated signal at IC<sub>2</sub>'s pin 24. This signal undergoes passive filtering and amplification by the audio power amplifier IC<sub>3</sub> before producing an audible word at the speaker.

**EDN**

To Vote For This Design, Circle No 746

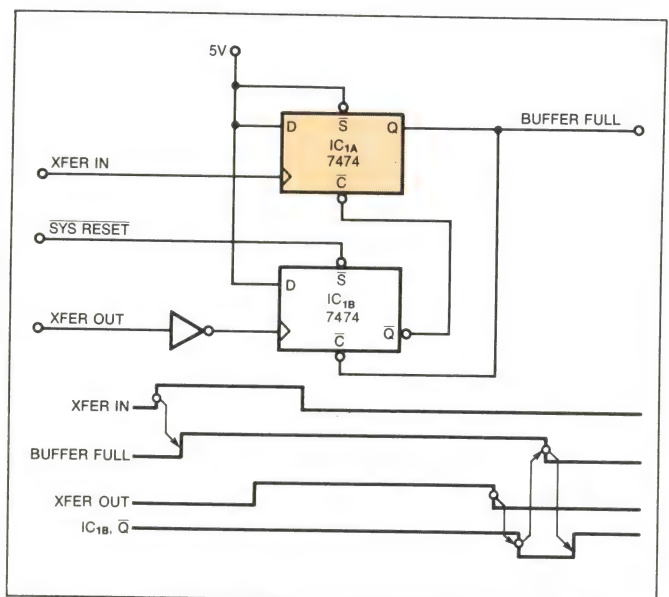
## Signal edges set and clear D flip-flop

Dan Kuechle  
Network Systems Corp, Minneapolis, MN

For a D flip-flop, set and clear ( $\overline{S}$  and  $\overline{C}$ ) are level-sensitive control inputs. The Fig 1 circuit, however, lets you set and clear such a flip-flop using the transitions of selected signals.

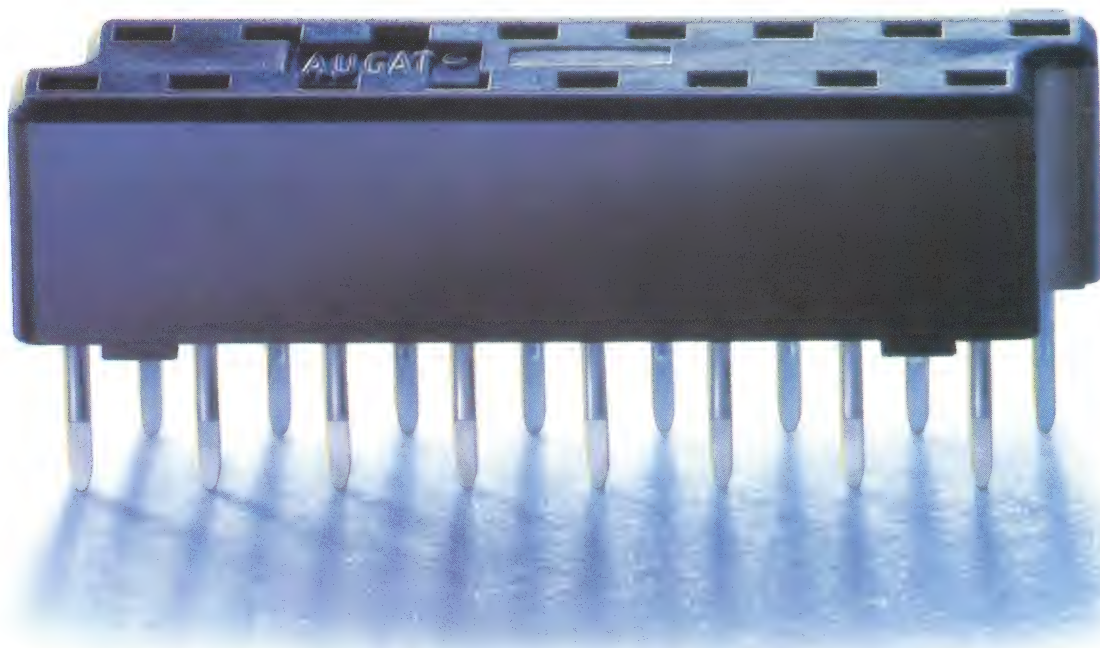
In this example, the flip-flop IC<sub>1A</sub> generates the active-high status signal that's labeled BUFFER FULL. External commands XFER IN and XFER OUT load and unload the buffer (not shown), but these two signals are not suitable for direct control of flip-flop IC<sub>1A</sub>. However, with the addition of IC<sub>1B</sub> as shown, IC<sub>1A</sub> sets on the low-to-high transition of XFER IN and clears on the high-to-low transition of XFER OUT. (The narrow  $\overline{Q}$  pulse from IC<sub>1B</sub> has a duration only twice the flip-flop's propagation delay, but this duration is sufficient to clear IC<sub>1A</sub>.)

**EDN**



**Fig 1**—In this configuration, flip-flop IC<sub>1A</sub> exhibits edge-sensitive set and clear controls: A low-to-high transition of XFER IN sets the device, and a high-to-low transition of XFER OUT clears it.

To Vote For This Design, Circle No 747



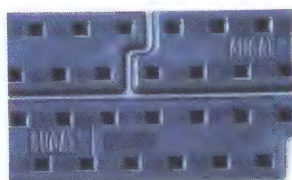
# SPACE ACE

Augat ZIP sockets use only half the space of DIP. For twice the memory on your board.

Now, Augat makes it easier to utilize ZIP packaging technology and double your board performance. With ZIP sockets that take up half the space of DIP.

They're the end-to-end, side-to-side stackable solution. With flat top and tapered tails for easy, pick-and-place automatic insertion.

Available now with high-reliability gas-tight contacts.



*Top view: Now you can socket DRAMs side to side and end to end.*

They come in 16, 20 and 24-pin footprints. For 256K DRAMs, 1-Mbit ICs and video DRAMs. Send us your size and we'll send you a sample. Free. Plus an insertion and extraction tool for a perfect fit.



Get ahead in the space race. With ZIP sockets. More innovation that works from Augat. The people you can count on to make the link between you and what's new in packaging technology.

Show me how ZIP sockets help me pack more memory into less space. Send me my free sample and insertion/extraction tool.

My footprint size is ☐ 16 pins ☐ 20 pins ☐ 24 pins.

My application is \_\_\_\_\_  
Name \_\_\_\_\_  
Title \_\_\_\_\_  
Company \_\_\_\_\_  
Street Address \_\_\_\_\_  
City \_\_\_\_\_ State \_\_\_\_\_  
Zip \_\_\_\_\_ Tel. \_\_\_\_\_

EDN010788

Mail to: Augat, Inc.  
Interconnection Components  
Division, 33 Perry Avenue,  
Attleboro, MA 02703, (617)  
222-2202. FAX: 617 222 0693

**AUGAT** INTERCONNECTION  
COMPONENTS

*Quality and Innovation*

## Design Entry Blank

**\$75 Cash Award** for all entries selected by editors. An **additional \$100 Cash Award** for the winning design of each issue, determined by vote of readers. **Additional \$1500 Cash Award** for annual Grand Prize Design, selected among biweekly winners by vote of editors.

To: Design Ideas Editor, EDN Magazine  
Cahners Publishing Co  
275 Washington St, Newton, MA 02158

I hereby submit my Design Ideas entry.

Name \_\_\_\_\_

Title \_\_\_\_\_ Phone \_\_\_\_\_

Company \_\_\_\_\_

Division (if any) \_\_\_\_\_

Street \_\_\_\_\_

City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_

Design Title \_\_\_\_\_

Home Address \_\_\_\_\_

Social Security Number \_\_\_\_\_  
(Must accompany all Design Ideas submitted by US authors)

**Entry blank must accompany all entries.** Design entered must be submitted exclusively to EDN, must be original with author(s), must not have been previously published (limited-distribution house organs excepted), and must have been constructed and tested.

Exclusive publishing rights remain with Cahners Publishing Co unless entry is returned to author or editor gives written permission for publication elsewhere.

In submitting my entry, I agree to abide by the rules of the Design Ideas Program.

Signed \_\_\_\_\_

Date \_\_\_\_\_

**Your vote determines** this issue's winner. All designs published win \$75 cash. All issue winners receive an additional \$100 and become eligible for the annual \$1500 Grand Prize. **Vote now**, by circling the appropriate number on the reader inquiry card.

### ISSUE WINNER

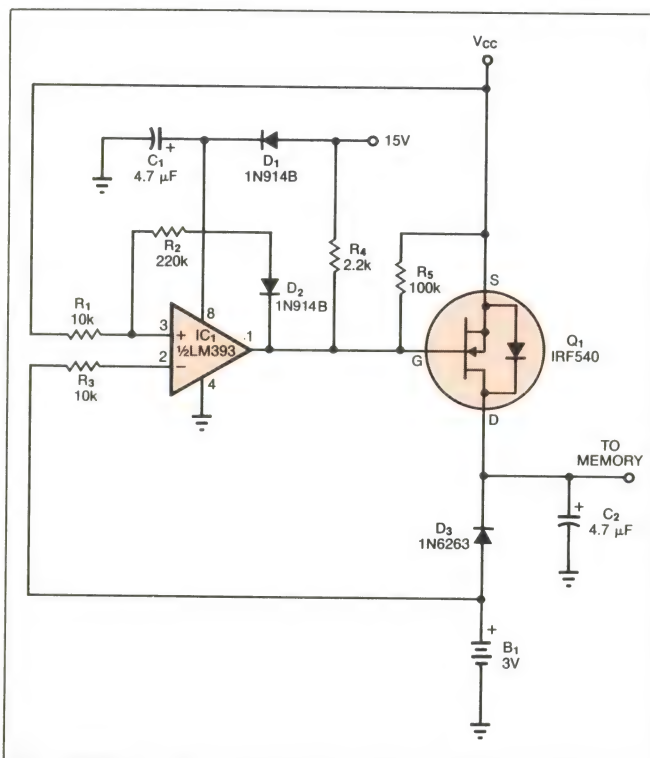
The winning Design Idea for the October 1, 1987, issue is entitled "V/I converter has zero  $I_B$  error," submitted by Roberto Burani and Giovanni Stocchino of FATME SpA (Rome, Italy).

## MOSFET switches memory-supply current

Steve Mowry

Texas Instruments Inc, Johnson City, TN

In Fig 1, the MOSFET serves as a switch that connects the memory with  $V_{CC}$  only when that supply voltage is present. The battery  $B_1$  supplies standby current to the memory when  $V_{CC}$  falls below the battery voltage.



**Fig 1—This circuit connects  $V_{CC}$  to memory when voltage is present;  $Q_1$  can pass 1A while dropping less than 80 mV. The circuit provides battery backup when  $V_{CC}$  is not present.**

The MOSFET  $Q_1$  is off (open) when  $V_{CC}$  is less than the  $B_1$  battery voltage. When  $V_{CC}$  rises above the battery voltage, the output of comparator  $IC_1$  switches high and turns on  $Q_1$  for operation in the inverted mode. In this condition,  $Q_1$  can pass 1A while dropping less than 80 mV. As  $V_{CC}$  drops,  $Q_1$  turns off before the battery can discharge. The components  $R_2$  and  $D_2$  prevent oscillation by adding hysteresis to the comparator.

**EDN**

To Vote For This Design, Circle No 748



**Discover  
Fluoronics Resources**

# Fluorinert™ Liquids—products that power Fluoronics Resources

## \*Fluoronics Resources:

An exclusive 3M combination of innovative products backed by research and development, manufacturing expertise, technical data and service assistance built on more than 35 years' experience of pioneering in fluorochemistry.

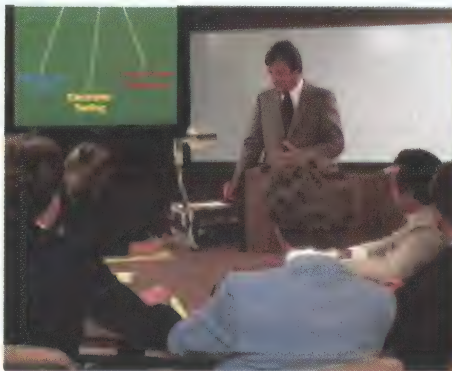
3M has had a whole generation of experience in the development, manufacture and refinement of perfluorinated liquids. We first introduced these versatile liquids to electronics design, testing and production professionals in the fifties. Since then, Fluorinert Liquids have become the mainstays in electronic cooling, high reliability testing and vapor phase soldering.

Fluorinert Liquids, used as a direct contact heat transfer medium, offer a range of physical properties that make them particularly suitable for electronic uses. They are non-polar and exhibit no solvent action. They are colorless, low in toxicity, non-flammable and offer exceptionally high dielectric strength plus thermal and chemical stability. Most important, they have almost no chemical reactivity and they evaporate without leaving a residue on parts.

### Buy the numbers

Our FC™ numbers — FC-40, FC-70, FC-77, etc. — are used to identify Fluorinert Liquids that offer certain physical characteristics to meet specific application needs. These FC numbers are solely 3M designations for various fluorochemical products.

Fluorinert Liquids are being used cost-effectively in cooling, high reliability testing and vapor phase soldering operations. When you are interested in applying these versatile liquids in your own production, 3M can provide an abundance of technical information and support.



### Technical assistance: the main benefit of Fluoronics Resources

3M offers prompt assistance to help you solve many production and testing problems. We provide comprehensive technical recommendations for specific fluids. We consult with you on the proper application equipment and help you evaluate production methods and results. Our service bulletins bring you up to date on the most recent advances in vapor phase soldering and high reliability testing. Ask us about 3M's audiovisual materials and on-site application training seminars.

### Discover Fluorinert™ Liquids' heat transfer capability

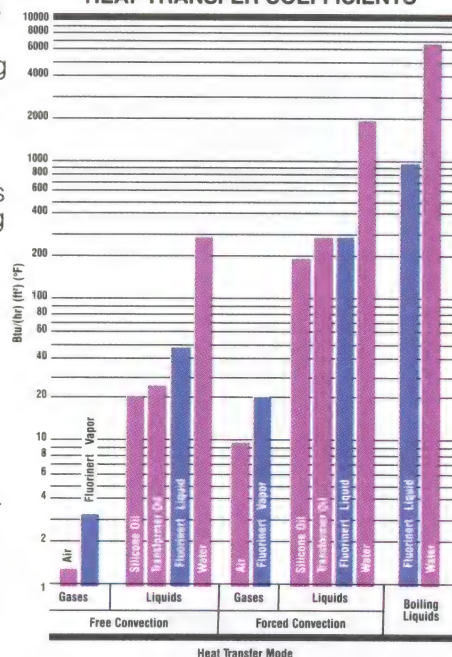
What are your needs? A precise degree of temperature control? Fast, uniform heat transfer? High dielectric strength? Fluorinert Liquids offer the broad range of physical characteristics required in most applications.

Fluorinert Liquids are an effective direct contact heat transfer medium whether used in a liquid or vapor state. Their unique properties enable you to use them in contact with sensitive components and substrates.

Major differences between the various products in the Fluorinert Liquids family can be seen in their boiling points. These can range from 56°C to 253°C. Should you need products with intermediate boiling temperatures, the 3M staff will work with you to fashion a product especially for your needs. It's an example of how 3M's Fluoronics Resources provide you with "customized" service to solve special problems.



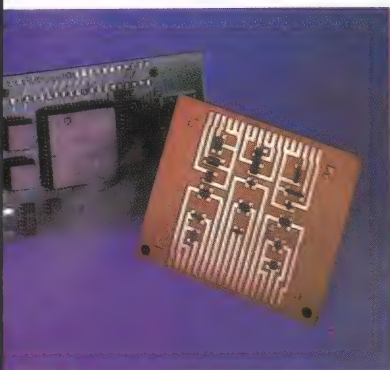
COMPARATIVE  
HEAT TRANSFER COEFFICIENTS



### Fluorinert™ Liquids achieve accurate high reliability testing

It's a small world you work in. Where time ticks in nanoseconds and dimension is measured in Angstrom units. And as circuitry becomes more complex, a greater demand is placed on testing capability — not only in speed, but in higher reliability and accuracy.

Fluorinert Liquids meet those requirements by providing a controlled temperature environment and a high degree of electrical protection. They offer maximum compatibility between



the heat transfer medium and the device under test. Fluorinert Liquids reduce testing costs by reducing testing time substantially. They do this by rapidly reaching test temperature and providing precise and uniform temperature control. You'll minimize the number of faulty units by detecting defects before they become rejects.

These liquids provide cost-effective tests such as gross leak, thermal shock, liquid burn-in, ceramic crack detection, electrical environmental, temperature calibration and failure analysis/short detection.

Fluorinert Liquids are specified in the MIL-STD's for thermal shock and gross leak testing.

#### THERMAL SHOCK TEST CONDITIONS

Military Standard 883-1011			Military Approved Fluorinert Liquids	
Test Condition	Hot Test Step 1	Cold Test Step 2	Hot Test Step 1	Cold Test Step 2
A	100°C	-0°C	Water, FC-40	Water, FC-40, FC-77
B	125°C	-55°C	FC-40, FC-70, FC-5311	FC-77
C	150°C	-65°C	FC-40, FC-70, FC-5311	FC-77
D	200°C	-65°C	FC-70, FC-5311	FC-77
E	150°C	-195°C	FC-40, FC-70, FC-5311	Liq. N <sub>2</sub>
F	200°C	-195°C	FC-70, FC-5311	Liq. N <sub>2</sub>

#### GROSS LEAK TEST CONDITIONS

Military Standards	Military Approved Fluorinert Liquids		
	Indicator Fluids	Detector Fluids	Absorption Fluids
MIL-STD 883-1014	FC-40, FC-43	FC-72, FC-84	Do not apply
MIL-STD 750-1071	FC-40, FC-43	FC-72, FC-84	FC-43, FC-75, FC-77
MIL-STD 202-112	FC-40, FC-43	FC-72, FC-84	Do not apply

#### Discover higher yields in vapor phase soldering

Fluorinert Liquids have been the industry's fluid of choice since the vapor phase reflow soldering (VPS) process was introduced in 1975. There are a number of good reasons for this universal acceptance. VPS with Fluorinert Liquids produces highly reliable solder joints. The system reduces reject rates, increases production, and lowers production costs. With Fluorinert Liquids, you can be assured that your products will never be exposed to a temperature higher than the selected liquid's boiling point. (See above)

You'll avoid those problems usually associated with other systems — shadowing, uneven heating, and overheating. The liquids are non-flammable. Their low surface tension helps them evaporate quickly from the work pieces without leaving a residue.

VPS with Fluorinert Liquids is especially suited for boards with high mass or complex geometries. The liquid vapors completely surround the assembly and penetrate remote recesses to heat all surfaces evenly. The vapors are 15 to 20 times heavier than air so they can be contained easily within the work area. The system offers an oxygen-free, non-corrosive environment to minimize rejects from oxidation contamination.

Some typical applications using Fluorinert Liquids in VPS include surface mounted leaded or leadless components, through-hole leads and wire-wrap pins, lead frame attachment, reflow of electroplated solder or tin and miscellaneous metal joining.

#### VPS SELECTION GUIDE

Fluorinert Liquid	Boiling Point	Typical Solders
FC-43	174°C/345°F	70 Sn/18 Pb/12 In 100 In 58 Sn/42 In 58 Bi/42 Sn
FC-70, FC-5311 FC-5312	215°C/419°F	63 Sn/37 Pb 60 Sn/40 Pb 62 Sn/36 Pb/2 Ag
FC-71	253°C/487°F	100 Sn 95 Sn/5 Ag 60 Pb/40 Sn

#### Discover the unique cooling benefits of Fluorinert™ Liquids

As the package size decreases, your need for more efficient heat dissipation increases in proportion. 3M Fluorinert Liquids are very efficient as a direct contact heat transfer medium, with the added advantage of having the high dielectric characteristics needed to meet stringent demands of the diversified electronics industry. We offer 11 liquids with boiling points that range from 56°C to 253°C.

These stable liquids allow you to maximize power density and miniaturize your package. Yet they reduce failure rates and increase reliability.

Fluorinert Liquids are used in such demanding applications as:

- Radar transmitters • Power supplies
- High voltage transformers • Lasers
- Radar klystrons • Computer modules
- Computer memories • Fuel cells

Typical properties of Fluorinert Liquids used in cooling are:

Fluorinert Liquid FC-77 (English Units)	Liquid		Vapor
	Room Temp. (77°F)	Boiling Point (207°F)	Boiling Point 207°F @/ATM
Density lb./ft. <sup>3</sup>	111	100	0.85
Thermal Conductivity Btu/(hr) (ft. <sup>2</sup> ) (°F/ft)	0.037	0.033	0.008
Specific Heat Btu/(lb.) (°F)	0.25	0.28	0.23
Viscosity c.p.	1.42	0.46	0.02
Coefficient of Thermal Expansion ft. <sup>3</sup> /(ft. <sup>3</sup> ) (°F)	0.0008	0.0009	0.0015

#### Discover heating/curing with Fluorinert™ Liquids

Because they maintain their vapor temperature with absolute precision, Fluorinert Liquids can be used in many heating and/or curing operations. They serve as heat transfer media in solder mask and polymer thick film applications and for polymer processing. The non-corrosive vapors will not support oxidation. Ideal where solvent flash-off is a problem.

# 3M

# Discover Fluoronics Resources

**3M presents a unique short course in the use of Fluorinert™ Liquids for the electronics industry.**

3M is now offering a series of "Applied Fluoronics" tapes demonstrating how Fluorinert Liquids are used in a number of applications. See first hand how these remarkable products can improve overall electronic production.

Three cassettes are available:

1. "Applied Fluoronics: High Reliability Testing"
2. "Applied Fluoronics: Vapor Phase Soldering"
3. "Applied Fluoronics: Direct Contact Cooling"

These informative VHS format tapes are available to qualified personnel in the electronics industry. Specify which cassette(s) you would like to view.

Write on your company letterhead, describing your general interest. Mail to: Fluoronics Resources, Industrial Chemical Products Division/3M, Building 223-6SE-04, 3M Center, St. Paul, MN 55144-1000.

For technical information or assistance on High Reliability Testing and Cooling, call 612/733-6282; for Vapor Condensation Heating assistance, call 612/733-7424.



# 3M

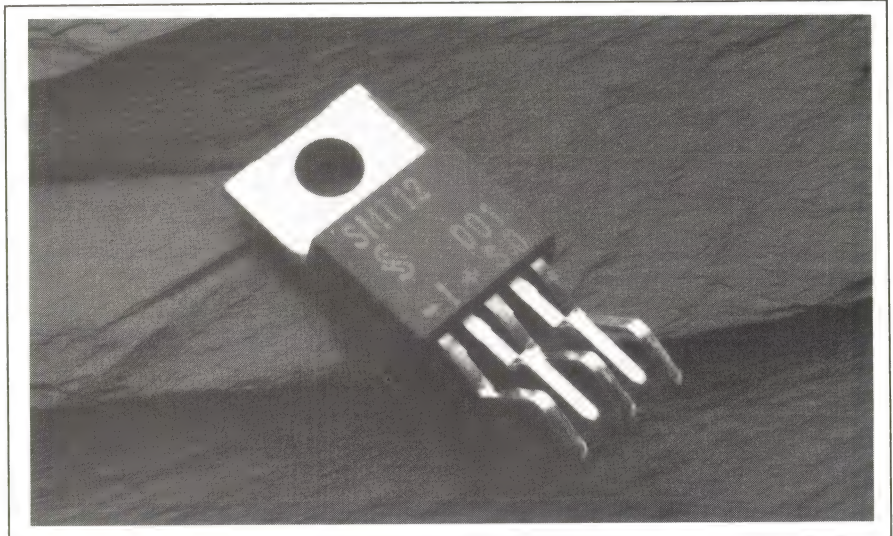
# NEW PRODUCTS

## INTEGRATED CIRCUITS

### SMART SWITCH

- Has 35V/12A rating
- Features built-in diagnostic capability

Fabricated using SIPMOS technology, the BTS-412A is a smart MOS power switch that features built-in protection functions. SIPMOS technology integrates 5V-CMOS and high-voltage-CMOS structures with vertical power MOSFETs without using junction or dielectric isolation. Targeted at automotive and industrial applications, the device is fully protected against overloads, under-voltage, short circuits, and junction temperatures exceeding 150°C. Available in a TO-220 package, it operates to 35V and has a maximum load-current rating of 12A. In its off

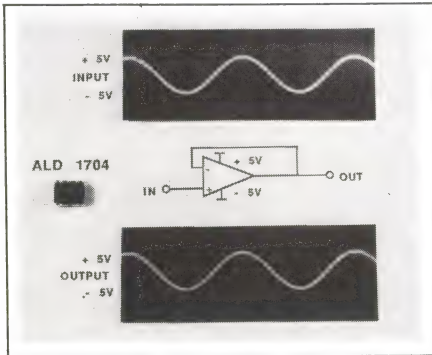


state, the device will block 45V at very low standby current consumption. \$6.25 (1000).

Siemens Components Inc, Power

Semiconductor Div, 2191 Laurelwood Rd, Santa Clara, CA 95054. Phone (408) 980-4545.

Circle No 351



### CMOS OP AMP

- Low-power alternative to J-FET op amps
- Has 5V/ $\mu$ sec slew rate

The ALD-1704 CMOS op amp provides a low-power and low-cost alternative to J-FET op amps. The device has a slew rate of 5V/ $\mu$ sec and a bandwidth of 2.1 MHz when operating from dual supplies of  $\pm 3.25$  to  $\pm 6$ V. Its power dissipation is 45 mW at a supply voltage of  $\pm 5$ V. The IC offers rail-to-rail input- and output-voltage ranges, and its output-current rating is 10 mA. The output is short-circuit protected to 15 mA. The manufacturer

offers four input offset-voltage grades: 10-mV 1704G, \$1.36; 4.5-mV 1704, \$1.51; 2-mV 1704B, \$2.57; and 0.9-mV 1704A, \$3.58 (100). A military ceramic DIP is available for all grades.

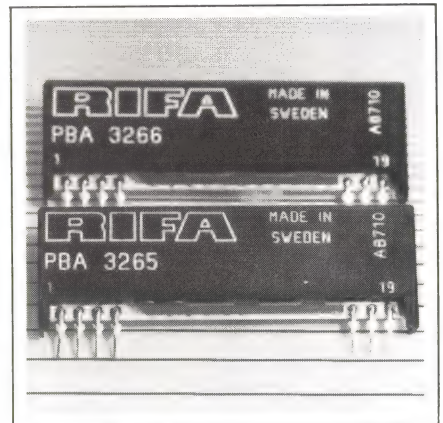
Advanced Linear Devices, 1030 West Maude Ave, Sunnyvale, CA 94086. Phone (408) 720-8737. TLX 510-100-6588.

Circle No 352

### DIGITAL FILTER

- Features 20-kHz cut-off frequency
- Has optional delay equalizer that corrects phase response

The PBA-3265 lowpass filter operates as a band-limiting, antialiasing filter in digital audio systems with 48- to 50-kHz sampling rates. The device's frequency response is stable to within 0.1 dB from dc to 20 kHz. Its stop-band attenuation is 80 dB min from 24 to 100 kHz. The PBA-3266 matching delay equalizer corrects the filter's phase response.



The resulting group-delay variation is constant within  $\pm 30 \mu$ sec for frequencies to 19 kHz. You can employ its built-in sin x/x compensation network to facilitate the use of the filter/equalizer combination as a reconstruction filter following a D/A converter. The sin x/x section is designed for a system that provides a 48-kHz sampling rate. Each circuit comes in a single-in-line package. PBA-3265, \$24.50; PBA-3266, \$29.50 (100).

Rifa Inc, Box 3110, Greenwich, CT 06836. Phone (203) 625-7300.

Circle No 353

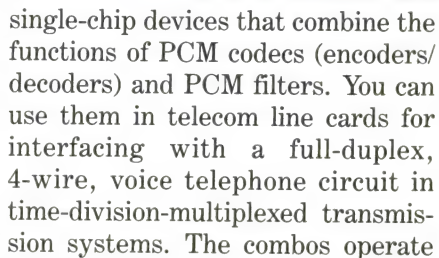


- Is a 2- $\mu\text{m}$  CMOS device
- For use in 48-mA bus-transceiver applications

**VLSI Technology Inc, 8375**  
South River Parkway, Tempe, AZ  
85284. Phone (602) 752-8574.

## CMOS COMBOs

- The TCM29C13, TCM29C14, TCM29C16, and TCM29C17 CMOS combos directly replace the 2913, 2914, 2916, and 2917 NMOS-type ICs and dissipate 40% less power. They have a typical power dissipation of 80 mW when in operation and of 5 mW when on standby. Their power-supply rejection specs are 30 dB from 0 to 50 kHz. Combos are



single-chip devices that combine the functions of PCM codecs (encoders/decoders) and PCM filters. You can use them in telecom line cards for interfacing with a full-duplex, 4-wire, voice telephone circuit in time-division-multiplexed transmission systems. The combos operate

# Color by

08

from 0 to 70°C and use  $\pm 5V$  supplies. They come in ceramic DIPs, plastic DIPs, and small outline packages. \$7.01 to \$8.47 (100).

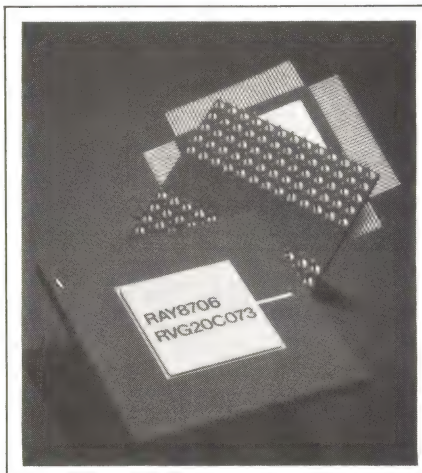
**Texas Instruments Inc.**, Semiconductor Group (SC-777), Box 809066, Dallas, TX 75380. Phone (800) 232-3200.

Circle No 355

## CMOS GATE ARRAYS

- Have unloaded inverter delay of 0.4 nsec
- Feature 1.25- $\mu m$  technology

RVG CMOS gate arrays incorporate rad hardening and have 5670 to 20,440 2-input gates. Representative arrays include the 5670-gate RVG5, the 10,360-gate RVG10, the 14,640-gate RVG15, and the 20,440-gate RVG20. The 2-input NAND gate has a delay of 0.95 nsec with a fan-out of 2; its typical power dissipation is only 8  $\mu W/MHz$ . The gate



arrays feature symmetrical switching and edge delays, operate at 250-MHz flip-flop frequencies, and are TTL/CMOS compatible. Each I/O interface includes protection circuitry for a 2000V electrostatic discharge and is user programmable as an input, output, or bidirectional signal connection. You can select from an extensive macrocell library of SSI, MSI, and LSI functions.

Military and commercial NRE (non-recurring engineering) costs, from \$35,000; military devices, from \$150 (1000/year); commercial devices, from \$65 (10,000/year).

**Raytheon Co.**, Semiconductor Div, 350 Ellis St, Mountain View, CA 94043. Phone (415) 968-9211.

Circle No 356

## CODEC/FILTER

- Is compatible with AT&T and CCITT telephone standards
- Features a low transmit idle-channel noise level

The M5913 CMOS codec/filter IC provides the A/D and D/A conversion and the transmit and receive filtering required to interface a full-duplex voice circuit to a time-division-multiplexed PCM digital telephone system. The device is compatible with AT&T's D3/D4 standard and with applicable

# Brooktree®



**Macintosh II.** 640x480 resolution, displays 256 colors simultaneously from a 16.8 million color palette.

**Bt453.** Triple 8-bit 40 MHz RAMDAC with 256 color lookup table. Monolithic CMOS.

Brooktree Corporation, 9950 Barnes Canyon Road, San Diego, California 92121. 1-800-VIDEO IC or 1-800-422-9040, in California.

Apple® and Macintosh™ II are trademarks of Apple Computer Corporation.



CIRCLE NO 13

CCITT standards. It has a power-supply rejection ratio of -40 dB from dc to 150 kHz. You can operate the codec at either a fixed data-rate or in a variable data-rate mode. To ensure the integrity of the PCM highway, the unit contains power-on-reset circuitry and circuitry that permits detection of an interrupted clock. The device operates from  $\pm 5V$  supplies and has a typical active power dissipation of 60 mW. Approximately \$6 (1000).

**SGS Microelectronics SpA**, Via C Olivetti 2, 20041 Agrate Brianza, Italy. Phone (039) 65551. TLX 330131.

**Circle No 357**

**SGS Semiconductor Corp**, 1000 E Bell Rd, Phoenix, AZ 85022. Phone (602) 867-6100. TLX 249976.

**Circle No 358**



## 8-BIT VIDEO DAC

- Accepts TTL inputs
- Provides 1V p-p output signal into 75 $\Omega$

The AH50008 8-bit composite-video D/A converter serves both monochrome and color digital-display applications. The converter accepts 8-bit video data, as well as synchronizing and blanking commands, directly from TTL sources. The converter has RS170A- and RS343A-compatible outputs, which can provide a 1V p-p signal at a 90-MHz update rate into a 75 $\Omega$  coaxial cable and monitor. The output transitions are virtually glitch-free and require no additional processing. The device comes in a 24-pin hermetically sealed DIP and

operates from -55 to +100°C. \$50 (100).

**Analogic Corp**, Data Conversion Products, 360 Audubon Rd, Wakefield, MA 01880. Phone (617) 246-0300.

**Circle No 359**

## SYNTHESIZER IC

- Allows direct synthesis of sine waves via a D/A converter
- Suited to fast frequency-hopping applications

The SP2001 is a digital frequency synthesizer that directly generates the 8-bit DAC code required to produce sine waves at frequencies between 5 kHz and 100 MHz. Because this method of generating sine waves eliminates the delays inherent in PLL synthesizers, the time it takes to hop between one frequency and another is affected only by the D/A converter's settling time; with a suitable D/A converter, you can achieve worst-case frequency-hop delays of about 17 nsec. This system also achieves close-to-carrier noise levels of -135 dBc/Hz. Fabricated in ECL technology, the unit requires -5.2 and -2V supplies. It comes in a 40-pin ceramic DIP. £375.

**Plessey Semiconductors Ltd**, Cheney Manor, Swindon, Wiltshire SN2 2QW, UK. Phone (0793) 36251. TLX 449637.

**Circle No 360**

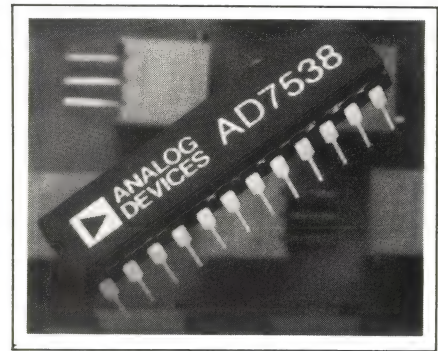
**Plessey Semiconductors**, 9 Parker, Irvine, CA 92718. Phone (714) 472-0303.

**Circle No 361**

## CMOS DAC

- Provides 14-bit accuracy and resolution
- Is TTL/CMOS compatible

The AD7538 multiplying D/A converter provides 14-bit accuracy and resolution over its full temperature range. Its integral and differential nonlinearity are  $\pm 2$  and  $\pm 4$  LSB, respectively. Double-buffered data latches and  $\mu P$  compatibility allow



simultaneous updating in systems that use multiple DACs. Using standard chip-select and memory-write commands, the current-output DAC is parallel-loaded by a single 14-bit word. Applications include microprocessor-based control systems, digital audio, and precision servo control. You can obtain the device in a 24-pin plastic or ceramic DIP. \$10.50 to \$51.90 (100).

**Analog Devices**, Box 9106, Norwood, MA 02062. Phone (617) 329-4700. TWX 174059.

**Circle No 362**

## 16-DIODE ARRAY

- MIL-S-19500 qualified to JAN, JANTX, and JANTXV
- On qualified product list

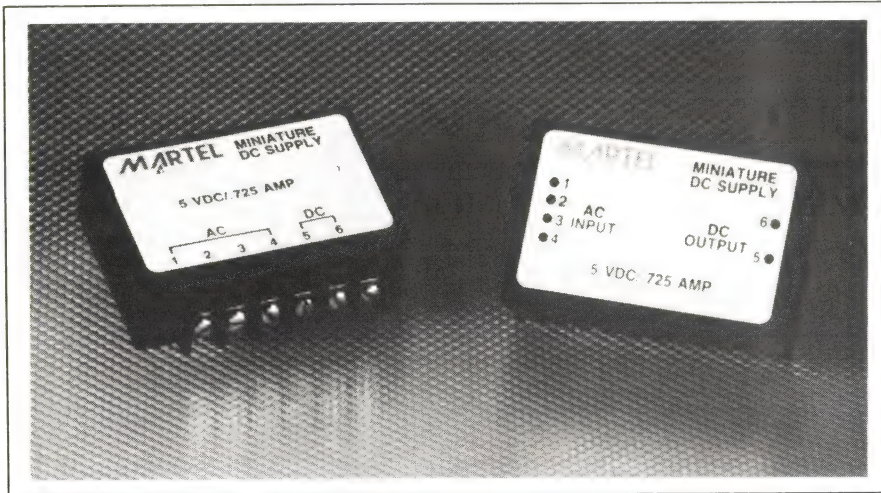
The 1N5772 16-diode array has eight common anodes and eight common cathodes brought out to two separate leads on a 10-lead flat pack. The other eight leads connect to the anode-cathode junctions of each of the eight series pairs. Each diode sustains a minimum breakdown voltage of 60V and a minimum current of 500 mA. Designed for high-speed military applications, the device meets the requirements of MIL-S-19500/474 and has typical switching speeds of less than 10 nsec. Its operating temperature-range is -55 to +150°C. JANTX version, \$21 (100).

**Silicon General**, 11861 Western Ave, Garden Grove, CA 92641. Phone (714) 898-8121. TWX 910-596-1804.

**Circle No 363**

# NEW PRODUCTS

## COMPONENTS & POWER SUPPLIES



### POWER SUPPLIES

- Designed to meet UL and CSA standards
- MTBF rating exceeds 100,000 hours

Available in both pc-board and chassis-mount configurations, Series 3000 ac to dc power supplies measure 1×2×3 in. and provide a 0.7W/in<sup>3</sup> power density. To achieve this high power density, the supply design employs an efficient semi-toroidal transformer that's matched with a proprietary, low-drop-out regulator. The supplies offer user-selectable input ranges of 105 to

125V ac and 210 to 250V ac and have outputs of 5V at 0.725A, 12V at 0.35A, and 24V at 0.175A. These miniature supplies feature line and load regulation of  $\pm 0.1\%$ . Short-circuit and overvoltage protection are standard. The units are designed to meet UL and CSA standards for power supplies and have a MTBF rating of more than 100,000 hours. \$37 for pc-board version; \$42.95 for chassis-mount model (100).

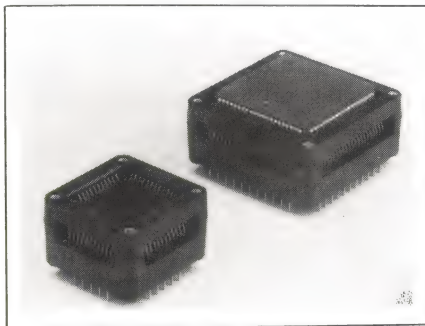
**Martel Electronics**, 27 Roulston Rd, Windham, NH 03087. Phone (603) 893-0886.

Circle No 364

### SOCKETS

- Guided-entry and -alignment ribs ease device orientation
- Socket design provides more contact area at the leads

Designed for burn-in service, these sockets accommodate 44- and 84-pin plastic leaded-chip carrier (PLCC) devices. They have a locking mechanism that facilitates manual or automated loading and unloading, prevents damage to delicate leads, and insures positive lead contact. A simple push seats the PLCC firmly in the socket with an audible click. A second push ejects the device above

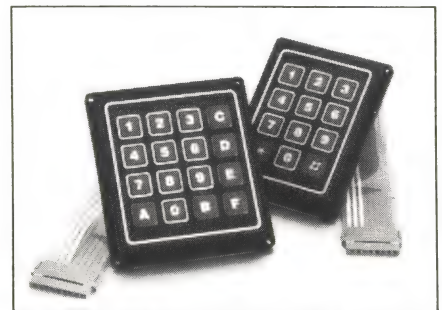


the socket edge for easy removal. Guided-entry and -alignment ribs ease the PLCC into proper orientation within the socket. An improved socket design provides more contact area at the top and sides of the leads to improve reliability. The sockets

feature quick visual polarization, and the side and bottom vents allow increased airflow for heat dissipation, as well as access for test probes. \$9.98 for the 44-pin unit; \$15.12 for the 84-pin version (1000).

**3M**, Dept EP87-109, Box 2963, Austin, TX 78769. Phone (512) 834-1803.

Circle No 365



### MEMBRANE KEYPADS

- 2- and 5-million-cycle lifetimes
- feature sealed splash-proof switches

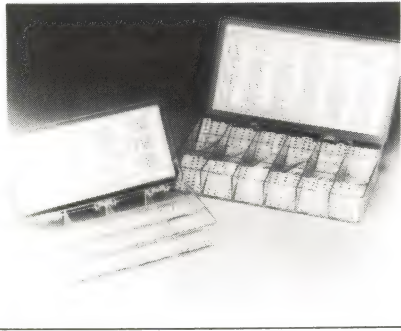
The Series 4000 membrane keypads are available in 4×4 and 3×4 arrays with either embossed, detented or flat nontactile keys. Sealed splash-proof switches, a built-in static shield, and chemically resistant graphics overlays are standard. The 4×4 arrays have hexadecimal graphics; the 3×4 arrays have standard telephone keypad graphics. The graphics are mounted on a rigid base, which has a UL 94V-0 rating, and are available in red, black, and white. The circuit configuration is an X-Y matrix output. The keypads terminate via a 6-in. flex tail that includes male and female connectors. The lifetime measures 2 million cycles for detent-type pads and 5 million cycles for nondetent-type units. \$5.53 (1000). Delivery, four to five weeks ARO.

**C&K Components Inc.**, 15 Riverdale Ave, Newton, MA 02158. Phone (617) 964-6400.

Circle No 366

*Electrochem Provides the Perfect Match  
Whatever Your Application*

EDN January 7, 1988



## CHIP KITS

- Ease problems in prototyping surface-mount circuits
- Include a complete selection of resistor and capacitor chips

The CR-1 chip resistor and CC-1 chip capacitor kits are designed to eliminate problems associated with prototyping surface-mount circuits. The CR-1 includes 1540 pieces composed of 10 chips of every 5% value from 10 $\Omega$  to 10 M $\Omega$ . The 0805-size chips cover values ranging to 3.3 M $\Omega$  and have a 100-mW rating; above 3.3 M $\Omega$ , the 1206-size chips have a 125-mW rating. The CC-1 kit contains 365 pieces (both 0805 and 1206 sizes) composed of five chip capacitors of every 10% value between 1 pF and 0.33  $\mu$ F. The kit contains NPO- (to 680 pF), X7R- (to 0.1  $\mu$ F), and Z5U- (above 0.1  $\mu$ F) type chips. \$49.95.

**Communications Specialists Inc.**, 426 W Taft Ave, Orange, CA 92665. Phone (800) 854-0547; in CA, (714) 998-3021.

Circle No 367

## MOSFET MODULES

- Current-sensing dice allow nearly lossless feedback circuits
- Electrically isolated bases allow direct mounting to heat sinks

CPY213E MOSFET modules provide nearly lossless feedback circuit designs. They include two n-channel HexSense die and two fast-recovery diodes paralleling two p-channel HexFET die in an H-bridge configuration. The on-resistance measures

0.18 $\Omega$  for the bottom-side n-channel devices and 0.3 $\Omega$  for the top-side p-channel devices, providing designers 6.1A/leg at 45°C. The sensing circuits on the HexSense dice are formed by isolating a number of cells on the HexFET die from the main-source metallization. Because each cell in the HexFET matrix is parallel and identical, sampling cur-

rent in one or several cells gives a scaled indication of the main current. The units are housed in low-profile (0.5-in.), 11-pin single-in-line packages. \$8.65 (1000). Delivery, four to eight weeks ARO.

**International Rectifier**, 233 Kansas St, El Segundo, CA 90245. Phone (213) 607-8939.

Circle No 368

ssssshh...

**Canon**  
fan motors  
at work

**ULTRA QUIET...AND...  
LARGE AIR FLOW  
BRUSHLESS DC FAN MOTORS**

**FEATURES**

- extremely low noise
- large air flow
- long-life, brushless
- low power consumption
- 12 and 24V dc models
- -10° to +70° C operation
- 24 models available

**APPLICATIONS**

- personal computers
- printers
- numerical control machines
- medical apparatus
- power supplies
- test equipment

Series	Rated V	Max. Air Flow CFM/min.	Noise Level dB	Rated Current mA
CF60-T	12	14-22	26-37.5	100-220
CF60-H	24	14-22	26-37.5	60-120
CF80-T	12	32-46	27-37	100-230
CF80-H	24	32-46	27-37	65-140
CF92-T	12	30-48	28-34	90-190
CF92-H	24	30-48	28-34	50-100
CF120-T	12	49-78	32-40	110-330
CF120-H	24	49-78	32-40	80-200

For more information call, write or circle reader response number.

**Canon**

**CANON USA, INC. COMPONENTS DIVISION**

New York Office/Headquarters One Canon Plaza, Lake Success, NY 11042 • 516/488-6700 • FAX 516/354-1114

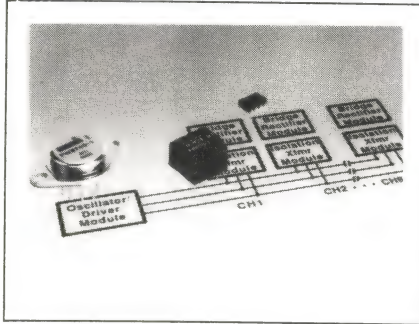
Santa Clara Office 4000 Burton Dr., Santa Clara, CA 95054 • 408/986-8780 • FAX 408/986-0230

Dallas Office 3200 Regent Blvd., Irving, TX 75063 • 214/830-9600 • FAX 214/830-9603

## CONVERTER SYSTEM

- Provides multiple channels of 7 to 20V dc at  $\pm 30$  mA
- Isolation guaranteed to 1500V ac

The PWS740 system provides multiple channels of 7 to 20V dc bipolar outputs with isolation 100% tested and guaranteed to 1500V ac. By sharing a common power driver



among several channels and using board-mounted transformers and rectifiers, you can generate bipolar isolated output as high as  $\pm 30$  mA. The system consists of three integrated components. The PWS740-1 is a 400-kHz oscillator/driver in a TO-3 package; it handles as many as eight separate signal channels. The PWS740-2 is a trifilar-wound isolation transformer with a ferrite core and is encapsulated in a compact plastic package. The PWS740-3 is a high-speed rectifier bridge housed in a plastic 8-pin DIP. When you're using two or more PWS740-1 modules, a sync pin synchronizes operation and eliminates troublesome beat-frequency switching noise. A TTL-compatible enable pin permits output shutdown. PWS740-1, \$12.75; PWS740-2, \$2.50; PWS740-3, \$1.25 (100).

**Burr-Brown Corp.**, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TLX 666491.

Circle No 369

## Higher frequencies. Smaller size.



ACTUAL SIZE

## NDK 1300 Series Compact Crystal Clock Oscillators

NDK's 1300 Series offers the widest range of CMOS- and TTL-compatible compact oscillators available. Frequencies from 28 kHz to 70 MHz with enable/disable std and dual-frequency output as an option. All in rugged, space-saving, half-size packages that are perfect for high density pc-board applications.

### NDK 1300 Series Features

- Broadest range of available frequencies — 28 kHz to 70 MHz
- Low-power/low-heat CMOS technology
- Choice of TTL, CMOS or dual-compatibility
- Compact size (0.52-inch square) — perfect for portables
- Quick rise and fall times (5, 7, 10 ns)
- Excellent fan out (2 or 5 TTL gates)
- Sealed, grounded metal case resists EMI, high temperatures, humidity
- Shock and vibration resistant

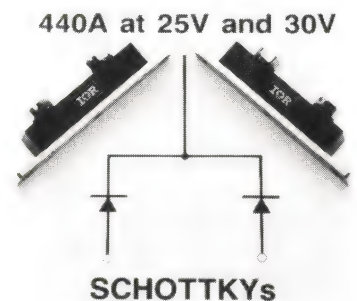
AVAILABLE FREQUENCIES					
28 kHz	3 MHz	22 MHz	25 MHz	70 MHz	
NDK 1300 Series Crystal Clock Oscillators					
Other Brands					

### NDK: Your single source.

NDK offers the widest range of compact crystal oscillators, microprocessor quartz crystals, and standard crystal oscillators available. All fully guaranteed to be free from impurities and defects. And all readily available through NDK's nationwide network of stocking distributors.

For a free product catalog, or to order evaluation samples, contact NDK today.

**NDK America, Inc.**  
20300 Stevens Creek Blvd., Suite 400  
Cupertino, CA 95014-2210  
Telephone: (408) 255-0831  
Telex: 352057 NDKCOLTD CPTO  
Fax: (408) 725-0369



## RECTIFIER MODULES

- Handle peak reverse voltages of 25 and 30V
- Operating range of  $-65$  to  $+150^{\circ}\text{C}$

The 440CNQ025/030 center-tapped Schottky rectifier modules handle maximum working peak reverse voltages of 25 and 30V, respectively, at currents as high as 220A/leg. The modules have a maximum peak forward voltage drop/leg of 0.59V at  $25^{\circ}\text{C}$ , a maximum peak 1-cycle non-

Large, angled marking surfaces for easy labeling and readability.

Non-burning, heat and humidity-resistant insulating material.

Coding system protects against misconnection without loss of poles.

Available in 2 to 24-pin vertical and horizontal configurations.

Captive screws.

Funnel-shaped entry for easy installation of wiring.



# EVEN THE COLOR IS BRILLIANT.

## Introducing the Weidmüller BLA/SLA Plug and Socket Connector System.

For years Weidmüller terminal blocks and connectors have set the standard all over the world in electrical and electronic connection systems. Now, our design engineers have come up with another brilliant solution. Our compact new BLA/SLA System for machine and process control circuit boards.

Our new design makes it quick and easy to install and repair wiring at the factory and in the field without expensive tools. Refinements include funnel-shaped wire entries, captive screws, and an improved

zinc-plated steel clamping mechanism for a secure connection.

The glass-filled polyester insulating material of BLA/SLA connectors is non-burning (UL94V-0) and heat and humidity resistant to maintain pin-to-pin spacing in adverse operating environments.

Marking surfaces on the sockets are large and angled for ease of labeling and reading.

The design of BLA/SLA connectors prevents misalignment. And, thanks to our simple new coding system, the BLA/SLA System provides protection against misconnection of plug and socket when you're using more than one connector. All without loss of poles.

Weidmüller BLA/SLA connectors are available in 2 to 24-pole modules. They come in



Doubleheader version available for increased wiring density.

both vertical and horizontal configurations. A double-header version is available for applications requiring even greater wiring density.

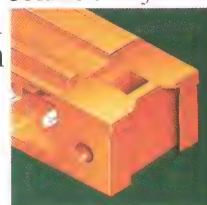
With so many standard features and with such options as supplementary mechanical mounting blocks and strain relief covers, we're confident you'll

find BLA/SLA the best system available for connecting discrete wiring to printed circuit boards.

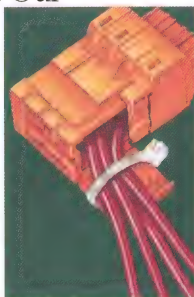
Call or write for more information about the Weidmüller BLA/SLA.

A system whose brilliance you'll appreciate even if you're color-blind.

**Weidmüller**   
You can't make a better connection.™



Optional mechanical mounting provides additional stability.



Optional cover with strain relief.

repetitive surge-current rating of 4000A, and a maximum continuous peak reverse current/leg of 40 mA. The maximum capacitance/leg is 9200 pF, and  $dV/dT$  equals 1000 V/ $\mu$ sec. The operating range spans -65 to +150°C. 440CNQ025, \$26.13; 440CNQ030, \$28.14 (100). Delivery, eight to 10 weeks ARO.

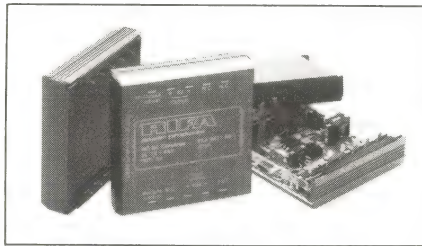
**International Rectifier**, 233 Kansas St, El Segundo, CA 90245. Phone (213) 607-8837.

**Circle No 370**

## DC/DC CONVERTER

- Provides 40W output power in a pc-board-mountable package
- Features 500V input-to-output isolation

The PKA 4411 PIL isolated dc/dc converter provides a 5V/8A output from a pc-board-mountable package that measures only 3×3×0.78 in.



The package's 0.78-in. height above the pc board allows mounting on boards that plug into racks on a 6TE (1.2-in.) spacing. The converter accepts dc input voltages in the range of 39 to 64V and has input-to-output isolation to 500V dc. Its predicted MTBF is more than 200 years at an ambient temperature of 45°C. The operating range is -45 to +65°C, but you can obtain another version, the PKA-4411-PI, which has an integral heat sink that extends its operating temperature range to 85°C. The extended temperature range version also has a 3×3-in. footprint, but its height is 1.39 in. A chassis-mount version with fast-on

terminals is also available. Approximately Swedish Krona 811 (100).

**Rifa AB**, Power Products Div, 16381 Stockholm, Sweden. Phone (8) 757-5000. TLX 10948.

**Circle No 371**

**Rifa Inc**, Greenwich Office Park 3, Greenwich, CT 06836. Phone (203) 625-7300.

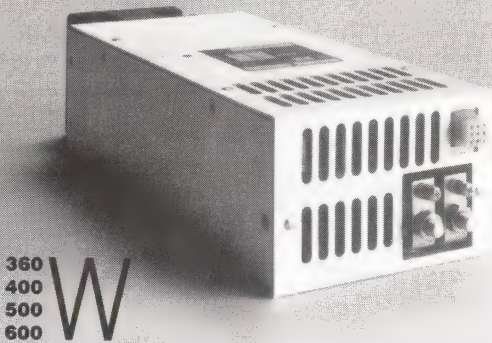
**Circle No 372**

## IC SOCKETS

- Designed for surface mounting
- Angled pins facilitate testing and troubleshooting

Type 105 and 117 IC sockets are designed for surface-mount applications. Type 105 units have angled pins (gull type) that provide easy access for in-circuit testing and troubleshooting. Type 117 units feature a floating-contact design that compensates for the effects of un-

## Series CV Compact Economy Switchers



### Compare to LH Series TMF !

*More power! Better specs! Better prices!*

- |                         |                  |
|-------------------------|------------------|
| ■ Safety & EMI          | ■ 42 models      |
| ■ Form & function equal | ■ 1-5 outputs    |
| ■ 2 year warranty       | ■ 5-48V, to 120A |
| ■ Direct from stock     |                  |

**Now for a limited time – purchase small quantities @ 100 piece price!**

Call Toll Free 1-800-523-2332

**Deltron inc.** P.O. BOX 1369 ■ WISSAHICKON AVENUE, NORTH WALES, PA 19454  
PHONE: 215/699-9261 TWX: 510/661-8061

## SIL-PAD K-10® OUTPERFORMS BERYLLIA.



**Compare PRICE, PERFORMANCE and RELIABILITY and Sil-Pad K-10 easily outperforms Beryllia.**

Sil-Pad K-10 combines DuPont's thermally filled Kapton® polyimide film and high performance Sil-Pad rubber to provide superior heat transfer, excellent cut-through resistance and dielectric strength. Yet Sil-Pad K-10 is a fraction of the cost of beryllia. Sil-Pad K-10 doesn't crack or fracture like fragile ceramic insulators. And, like all Sil-Pad products, Sil-Pad K-10 lowers your installed cost because it requires no grease.

Call Toll Free 1-800-328-3882 Today!

*When Performance Counts*

**BERGQUIST**

5300 Edina Industrial Blvd., Minneapolis, MN 55435. (612) 835-2322

# Mallory-brand Aluminum Electrolytics



## Selecting this outstanding capacitor line just became an even wiser decision.

**Because the company that makes them is now easier to work with.** When RTE bought Mallory's aluminum electrolytic business, they didn't change a great product. It's still made on the same production lines by the same skilled work force.

What did change was the level of customer service — at the plant and in the field — to make it easier for you to get specifications, samples or engineering help, and check delivery schedules. Now when we give you a shipping date, we meet it or beat it 99% of the time!

How has all this been accomplished?

**At the plant,** by adding seasoned specialists, an in-

house CAD-assisted engineering department, and a computerized order entry/customer service expediting system.

**In the field,** by assigning all Aerovox M aluminum electrolytics to the service-driven rep and distributor organization of our sister RTE company, Aerovox Inc., one of the world's largest capacitor makers, and a leading supplier of EMI filters.

So, next time you need aluminum electrolytics, call your Aerovox rep, or us, direct... because our product is still outstanding. And now, so is our service!

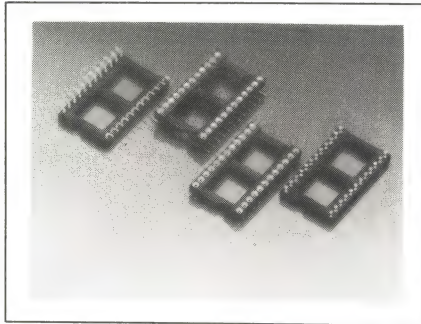
Now we're **Aerovox**  
**MALLORY\***

Send for our  
new Aerovox M  
technical bulletins  
today.

Glasgow, Kentucky 42141  
(502) 651-8301 • FAX 502-651-9312

\*MALLORY is a trademark owned by and used under license from Emhart Industries, Inc.

evenly dispensed solder paste. Both types can accommodate most soldering processes that are used for surface-mount fabrication. The insulator body is glass-filled thermoplastic polyester with a UL 94V-0 flammability rating. The contacts use a 4-finger clip made from stamped beryllium copper, gold, or tin plate over copper and nickel. The pins are



screw-machined brass with tin plating over copper and nickel. Types 105 and 117, with 28 pins and tin plating, cost \$1.75 and \$1.65 (100), respectively. Delivery, four to six weeks ARO.

**IEE Inc.**, Component Products Div, 7740 Lemona Ave, Van Nuys, CA 91409. Phone (818) 787-0311. TLX 4720556.

Circle No 373

## P r e c i s i o n Wirewound Resistors

*Competitive Price*

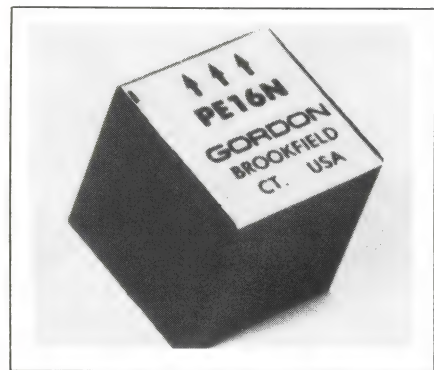
*Highest Quality*

*Fast Delivery*

- Wide Ohmic Range: 0.1Ω to 50MΩ
- Tightest Tolerances, to 0.005%
- Ratio Match to 0.001%
- TCR's: 0 ± 2ppm/°C to +6000ppm/°C
- TCR Match to 0.5ppm/°C
- Wide Selection of Style—Networks, Matched Sets, Hermetically-Sealed, Four Terminal, Low Reactance

**ELLIOTT JORDAN**

a Subsidiary of VISHAY Intertechnology, Inc.  
63 Lincoln Highway, Malvern, PA 19355  
(215) 644-1300/FAX: (215) 640-9081  
TWX: 510-668-5812



### SWITCHES

- Feature solid-state sensing and control circuits
- Designed to handle industrial environments

All the solid-state sensing and control circuitry of these pc-board-mountable metal-sensing proximity switches are epoxy cast in a 0.63×0.63×0.67-in. ABS housing. All the switches have complementary NO and NC outputs and operate from 5 to 12V dc voltages. An internal signal generator creates a sensing field at the front end of the switch. Any metal coming into the field will generate an output. Shielded switches, mounted on 0.63-in. centers, can sense a steel target at a 4-mm distance; unshielded switches have an 8-mm sensing range. The switch operation is not affected by light, noise, dirt, dust, water, oil, or other contaminants generally found in industrial environments. \$9.01 (1000).

**Gordon Products Inc.**, 67 Del Mar Dr, Brookfield, CT 06804. Phone (203) 775-4501.

Circle No 374

# 'REAL-TIME' SOLUTION TO ASIC VERIFICATION

**Tests Full Speed  
At Up to 50 MHz  
Across Entire Cycle.**



**F**or the first time, you can test your VLSI prototype design at real world operating speeds. Thoroughly and easily. Across the entire cycle. Without compromise.

Topaz is a totally-integrated ASIC verification system that reduces prototype characterization and fault analysis time, while offering these exclusive advantages:

- **Full Data Formatting to 50 MHz**—for quick measurement of set-up times and propagation delays.
- **256 I/O Channels at Speed, Without Multiplexing**—for maximum performance and flexibility.
- **Programmable Pattern Generation to 50 MHz**—for initiation of loops, branching and data control.

ASIC design requires painstaking accuracy. Verifying that design has been neither fast nor easy. The time available to get today's increasingly-complex ASICs to market continues to contract, and the price of an undetected error can be incredibly costly.

With Topaz, you'll know your design is right, and you'll know it *faster*. CAE-LINK™ software permits easy translation of simulator vectors into ready-to-use test vectors. And, our exclusive Meta-Shmoo™ software allows you to quickly sweep voltages and times *at 500ps increments across an entire cycle*, without programming.

It acquires data with a minimum of effort; and its ability to do graphic error-bit mapping and multi-level triggering gives it unequalled performance in failure analysis.

Topaz is a cost-effective solution to today's high speed ASIC verification needs, and the even higher speeds you'll require tomorrow. Call for complete details or your personal demonstration.

**HILEVEL**  
TECHNOLOGY, INC.

18902 Bardeen, Irvine, CA 92715  
Phone: (714) 752-5215

**DIAL TOLL FREE 1-800-HILEVEL**  
(In California 1-800-752-5215)

LITERATURE ONLY—CIRCLE 113

I WANT A DEMO—CIRCLE 152

# NEW PRODUCTS

## COMPUTERS & PERIPHERALS

### SCANNER

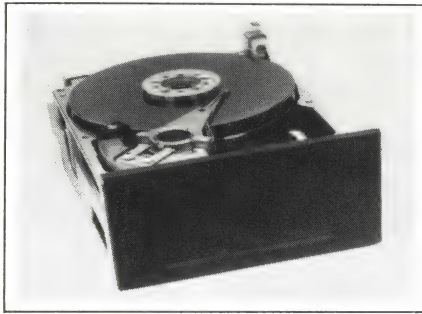
- *Recognizes 256 shades of gray*
- *Has resolution from 38 to 300 pixels/in.*

The PCScan 2000 desktop scanner interfaces with the IBM PC, PC/AT, PC/XT, PS/2, and compatibles or with an Apple Macintosh Plus, SE, or Macintosh II computer. The device performs 8-bit gray-scale scanning and thus recognizes 256 shades of gray. You can set its resolution from 38 to 300 pixels/in. It typically takes 9.4 sec to scan a page. You can edge feed documents from 3.5×3.5 to 8½×14 in. into a front entry port; an optional automatic feeder with 35-sheet capacity handles paper sizes from 6×6 to 8½×14 in. A SCSI interface connects the scanner to external devices. Two scanner models are available: one with and one without hardware that supports the vendor's optical recognition (OCR) soft-

ware. Model with OCR hardware, \$2195.

**DEST Corp**, 1201 Cadillac Ct, Milpitas, CA 95035. Phone (408) 946-7100. TLX 299823.

**Circle No 375**



### 3½-IN. DISK DRIVES

- *Have as much as 200M bytes of storage*
- *Support SCSI interface command set*

Swift Series 3½-in. disk drives come in eight models and have ca-

pacities of 55M, 100M, 150M, and 200M bytes. The 200M-byte model offers an average seek time of 16.5 msec. Other models have either 16.5-msec or 25-msec average seek times. One of the 200M-byte models supports instructions for the SCSI interface. Other models have either ESDI or ST506 interfaces. All the drives use thin-film media and feature a dedicated servo surface. They employ low-mass, straight-arm actuators for positioning the read/write heads. The 200M-byte drives can achieve 10M-bps data-transfer rates, whereas the other models transfer data at either 5M or 7.5M bps. Their power dissipation ranges from 10 to 12W, and they have an MTBF of 30,000 hours. Their operating temperature range is 10°C to 50°C. \$5 to \$8 per Mbyte.

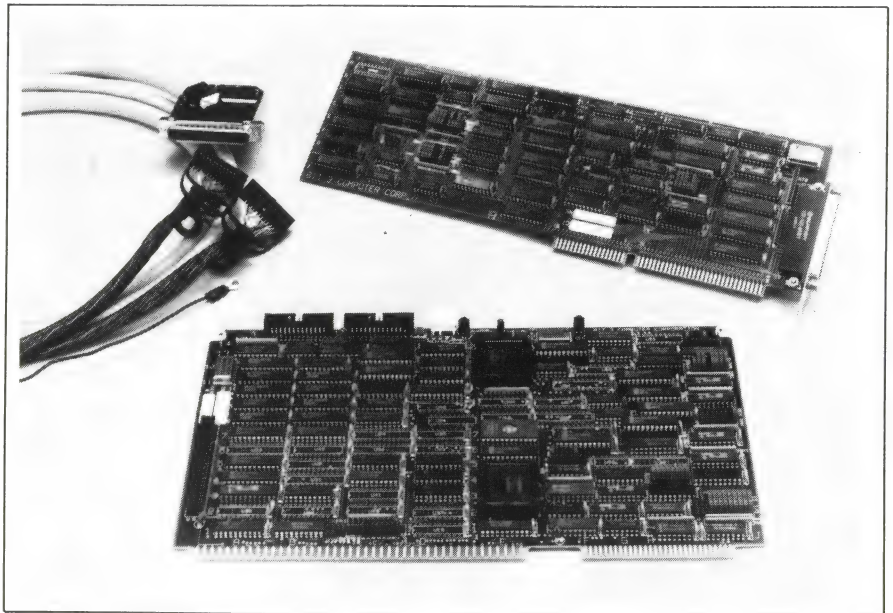
**Control Data Corp**, Box 0, Minneapolis, MN 55440. Phone (612) 853-5795.

**Circle No 376**

### BUS ADAPTER

- *Makes an IBM PC/AT the bus master of Multibus I*
- *Gives IBM PC/AT access to Multibus I devices*

The 404 IBM PC/AT Multibus I Adapter makes an IBM PC/AT function as a processor on Multibus I. The adapter permits the IBM PC/AT to serve as the bus master in Multibus applications and lets you use the wide variety of high-performance devices compatible with Multibus I. The product consists of two printed circuit cards. One card fits inside the PC/AT, whereas the other fits inside a Multibus card cage. The two cards are connected by an EMI-shielded cable. As much as 15M bytes of Multibus memory can serve as PC/AT memory. The 16M bytes of Multibus address



space are accessible in pages that range in size from 65k to 1M bytes. You can directly access Multibus I/O as PC/AT I/O. \$1380.

**Bit3**, 8120 Penn Ave S, Minneapolis, MN 55431. Phone (612) 881-6955.

**Circle No 377**



## DEECO DISPLAY SOLUTIONS. BECAUSE YOU HAVE ENOUGH TO DO.

You're a busy product designer. That's why Deeco has a wide range of flat-panel display solutions. Like vacuum fluorescent modules. Large-area electroluminescent and AC plasma controllers for graphics and text. PC, XT, AT adapters. And SealTouch™ infrared touch panels.

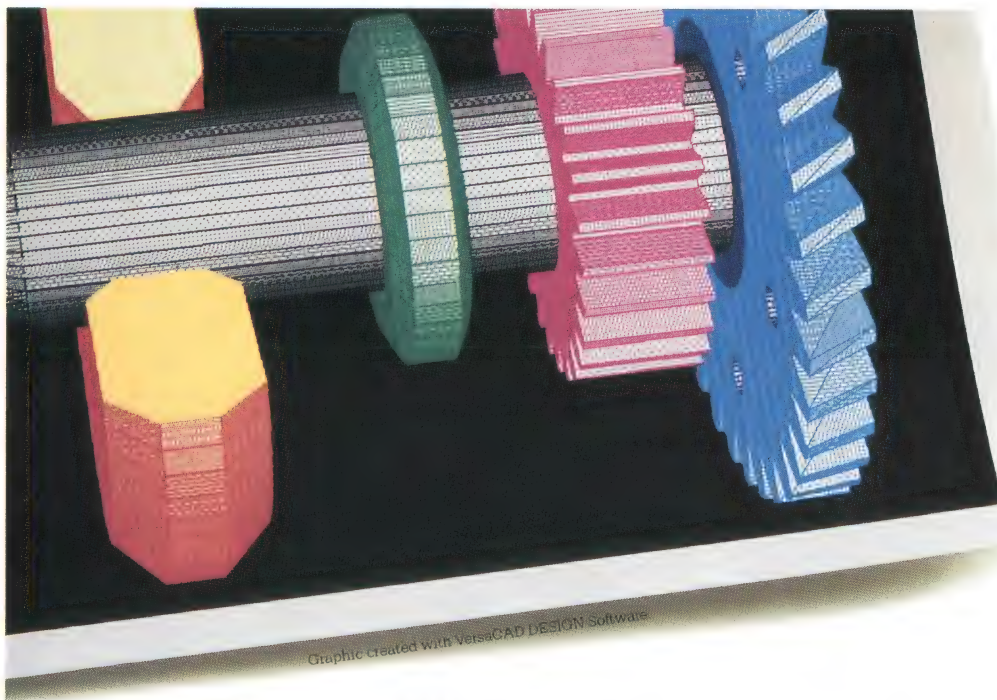
We make integrated solutions, too. Like our full flat-

panel module, with display, controller and SealTouch in a single assembly. It's the smallest solution to your large front panel problem.

Call or write for full product information. We know you're busy. Ask us for help, because you already have enough to do.

**Deeco**

Digital Electronics Corporation, 31047 Genstar Road, Hayward, CA 94544-7831 (415) 471-4700



we never  
stop  
asking

What if...

The new HP PaintJet color graphics printer.  
Great color is only 1/2 the story.



© 1987 Hewlett-Packard Co.

## COMPUTERS & PERIPHERALS

### VME BUS CONTROLLER

- Frees an extra board slot in a VME Bus system
- Includes controller functions and termination networks

The CC-101 system-controller module, which you plug onto the back of a VME Bus backplane's J1 connector, frees a board slot for a VME Bus card. The controller module measures 100×60 mm and includes both system-controller functions and active or passive termination networks. The system-controller functions include generation of the 16-MHz VME Bus system clock and 2.9-MHz serial clock; a 4-level priority or round-robin bus arbiter; bus time-out generator; and power-on or switch-activated reset operations. The board consumes 800 mA with active bus-termination networks and 1.7A with passive termination networks. It has an operating range of 0 to 70°C. \$280.

**CompControl bv**, Stratumseindijk 31, 5600 AD Eindhoven, The Netherlands. Phone (040) 124955. TLX 51603.

Circle No 378

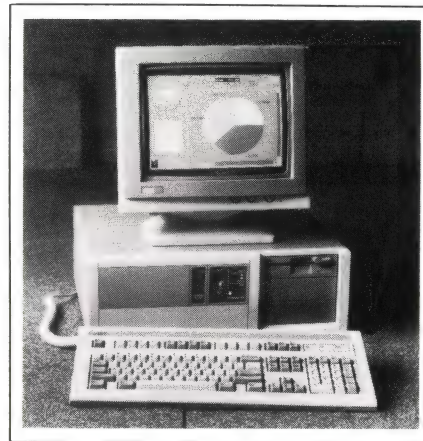
**CompControl Inc**, 15466 Los Gatos Blvd, Suite 109-365, Los Gatos, CA 95032. Phone (408) 356-3817. TLX 510-601-2895.

Circle No 379

### 80386 COMPUTER

- Uses IBM's Microchannel bus
- Is compatible with the PC/AT

The Premium/386 20-MHz 80386-based personal computer provides the multitasking benefits of IBM's Microchannel architecture and yet also features IBM PC/AT hardware and software compatibility. It is a single-user, multitasking machine suitable for CPU- and memory-intensive applications. You can obtain four models, all of which have seven



expansion slots, one 32-bit dedicated memory slot, three 16-bit PC/AT-compatible SmartSlots, one 8/16-bit standard PC/AT slot, and two 8-bit standard PC/XT slots. The SmartSlot architecture has three components: a dedicated 32-bit pathway from the processor to memory, a feature bus, and an arbitration bus. You can load coprocessors for graphics, communications, and disk control into the three

## HP PAINTJET PRINTER

### Description

Desktop color graphics printer for engineering use

### Color

6 colors plus black at 180 dpi; 330 colors at 90 dpi

### Text-Speed

NLQ at 167 cps (average page printed in 30-40 seconds)

### Software

Works with CAD and other popular software

### Compatibility

HP Vectra PC, IBM PC and compatibles

### Media

A-size paper or transparency film

### Price

\$1,395 US list

For a PaintJet-Pack, call 1 800 367-4772 EXT. 904A

we never  
stop  
asking

What if...

It can also print a page of text  
in 30 seconds flat.



HEWLETT  
PACKARD

© 1987 Hewlett-Packard Co.

CIRCLE NO 19

## COMPUTERS & PERIPHERALS

SmartSlots. Other features of the various models are memory capacities to 13M bytes, three user-selectable speeds, a disk controller, and hard disks of 40M- to 150M-byte capacity. A 1.2M-byte drive, a keyboard of 101 keys, two RS-232C ports, and one parallel port are standard on all the machines. The systems can each support as many as four drives. \$4695 to \$8995.

**AST Research Inc**, 2121 Alton Ave, Irvine, CA 92714. Phone (714) 863-1333.

Circle No 380

### OPTICAL-DISK DRIVE

- Provides 810M bytes of storage capacity
- Runs Winchester-drive software

The Model 810 optical-disk drive emulates magnetic-disk drives. The drive can run, without modification, software and operating systems de-

veloped for Winchester devices. It provides 810M bytes of storage capacity on a 5¼-in. removable cartridge. The double-sided cartridge conforms to ANSI standards. The drive's dual-μP architecture achieves 175-msec access times and data-transfer rates to 2.78M bps. The device has a SCSI host interface and is compatible with standard SCSI host adapters. A multitiered error-correction scheme provides a  $1 \times 10^{-12}$  corrected bit-error rate after error checking and correction (ECC) and a  $1 \times 10^{-16}$  undetected bit-error rate after ECC and cyclic redundancy checking (CRC). If you use the drive with an IBM PC/AT, you can employ system software that removes the 32M-byte disk-size limitation of DOS; this software occupies less than 10k bytes of host memory. In addition to the Winchester emulation mode, the drive also supports the write-once, read-many (WORM) mode. Single-drive

system, \$4995. Double-sided, 810M-byte cartridge, \$189. Delivery, 60 days ARO.

**LaserDrive Ltd**, 1101 Space Park Dr, Santa Clara, CA 95054. Phone (408) 970-3600.

Circle No 381

### SCSI CONTROLLER

- Controls as many as seven devices
- Provides 10M-bps transfer rates

The SM911 SCSI controller card for PC and PC/AT buses can control as many as seven serially chained floppy-disk drives or hard disks providing as much as 2.8G bytes of storage. The 4×4½-in. card consumes <10W and transfers data at a 10M-bps rate. It comes with 50- and 34-pin connectors for the control of internal floppy-disk drives, and with a 25-pin connector for the control of an external SCSI drive. The card's internal ROMBIOS contains

software drivers for two 33M-byte drives. Software drivers provided on floppy disks support large SCSI disks, optical drives, tape drives, Xenix operating systems, and the Novell operating environment. The board contains diagnostic routines that test the SCSI bus for connected drives, prepare the drives for use or formatting, and ascertain the type and size of the SCSI device. \$159.

**Tega Technologies Inc**, 1040 E Chapman Ave, Orange, CA 92666. Phone (714) 771-5128.

**Circle No 382**



## 12-LB LAP COMPUTER

- Uses 80C286  $\mu$ P
- Runs MS-DOS 3.2 Extended

The 1520 battery-powered lap computer is based on a 10-MHz 80C286  $\mu$ P and runs on MS-DOS version 3.2 Extended. It will run OS/2 when that software becomes available. Its standard features include a 10-in. LCD; 1M bytes of RAM; two 1.4M-byte, 3½-in. internal floppy-disk drives; and as much as 512k bytes of user-installable ROM. The computer comes with a 72-key keyboard, weighs 12 lbs, and is enclosed in a 2.3×11.5×15.0-in. magnesium case. It has an RGB video port, a 25-pin external floppy-disk-drive port, an RS-232C port, a parallel port, a port for an external keyboard, and a port for an expansion bus. Options include 640×200- and 640×400-pixel gas-plasma displays, a 40M-byte hard disk, an 80287 coprocessor, a 2400/1200/300-baud internal modem, internal and external NiCd rechargeable-battery packs, and ex-

pansion cartridges that offer 3270, video-graphics-adaptor (VGA), and GridLink LAN support. \$3495.

**Grid Systems Corp**, 47211 Lakeview Blvd, Box 5003, Fremont, CA 94538. Phone (415) 656-4700.

**Circle No 383**



## MULTIMETER

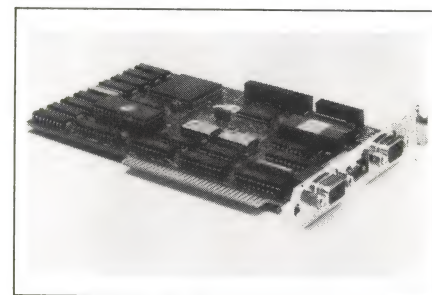
- Displays measurement data on a monitor
- Has adaptors that measure humidity, temperature, and rpm

The Multimeter Based Data Acquisition System is a multimeter with a built-in data bus that lets you display measured data on a computer monitor. The multimeter connects to an RS-232C-interface box, which in turn connects to your computer. The multimeter functions as a data recorder/analyzer or as automatic test equipment. It measures dc and ac voltage, dc and ac amperage, and resistance, and it checks diodes and transistors. Its dc-voltage measurement is accurate to within 0.5%. The multimeter operates from a 9V battery and has a built-in stand. The system's data-acquisition and communication software runs on an IBM PC, IBM PC/XT, IBM PC/AT, or compatible. You can enter the data manually or have it automatically entered. You can obtain optional adaptors to measure humidity, temperature, dc or ac current, rpm, light level, and air velocity. You can select data-transmission rates from 9600 to 1200 baud. An optional data transmitter and data receiver enable you to send data at 1200 baud over ordinary telephone lines without the need for a computer. Mul-

timer, \$89; RS-232C interface, \$149; DB-25 cable, \$29; software, \$29; transmitter, \$269; and receiver, \$269.

**Extech Instruments Corp**, 150 Bear Hill Rd, Waltham, MA 02154. Phone (617) 890-7440.

**Circle No 384**



## GRAPHICS CARD

- Displays all 17 IBM VGA modes on analog monitors
- Provides 800×560-pixel resolution

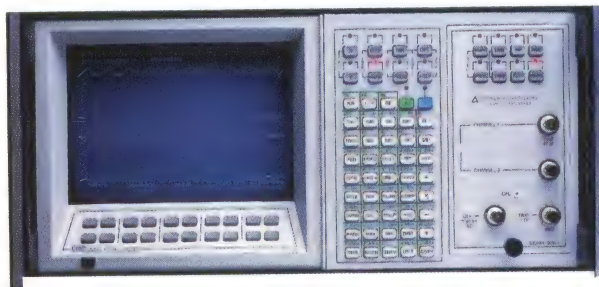
The VIP video graphics adapter (VGA) card works with the IBM PC, PC/XT, PC/AT, PS/2 Model 30, Compaq Portable PC, and compatibles. The card can display all 17 VGA modes on analog monitors. It can also display enhanced-graphics-adaptor (EGA) text and graphics on all IBM-compatible digital monitors. The card automatically switches to analog mode if you connect an analog monitor. Its Soft-Sense mode-switching feature switches your software to the correct mode. The card provides 800×560-pixel resolution max on multisync monitors and, in analog mode, can display as many as 256 of a possible 256,000 colors. The board also works with the color graphics adapter (CGA) and the Hercules monochrome graphics standard. The card comes with both 9- and 15-pin connectors for use with either digital or analog monitors. \$449.

**ATI Technologies Inc**, 3761 Victoria Park Ave, Scarborough, Ontario, Canada M1W 3S2. Phone (416) 756-0711.

**Circle No 385**

# Factory Floor Or Bench Top, It Tests Everything But Your Patience.

*At Up To 16 Bits/100 GHz, With Full Data Analysis Capability.*



## The DATA 6100 Universal Waveform Analyzer:

*From DSO applications to stand-alone production testing, the DATA 6100 has the signal processing power and versatility to get you answers faster, more cost-effectively, with unmatched resolution.*

For your demanding test and measurement requirements, there's no such thing as too much versatility, accessibility, and processing power. And nothing can meet your requirements like the DATA 6100 Universal Waveform Analyzer from Data Precision.

With the DATA 6100 you can perform complex test sequences without external computers. Conditionals, branching, looping, and subroutine capabilities are there when you need them. So are bidirectional IEEE-488 or RS232C communications.

Equally important, you get one-key access to more than 50 powerful signal processing and analysis functions. Modular digitizing plug-ins make the DATA 6100 extraordinarily cost-effective. You buy only the measurement capabilities you need now, expand them at will later.

Ultrafast settling time—to within 0.01% of final value in less than 10 ns—and rise times as fast as 350 ps let you characterize advanced analog components such as high speed D/ACs and op amps that are beyond the reach of other instruments.



And the DATA 6100's comprehensive, multi-level "HELP" functions make its outstanding power easily accessible. This is truly a test system that won't test your patience.

In vibration, acoustics, audio, biomedical, and scores of other applications, the DATA 6100 eliminates barriers between you and the data you're seeking.

## DATA 6100: Cost-effective versatility.

In one system you get an array of advanced capabilities, including ZOOM CZT for spectral resolution up to 65 times that of conventional FFTs.

The DATA 6100 functions as:

- ☐ A Digital Storage Oscilloscope
- ☐ A Spectrum Analyzer
- ☐ An Auto/Cross Correlator
- ☐ A Transient Analyzer
- ☐ A Vibration, Audio Signal, or Biomedical Signal Analyzer

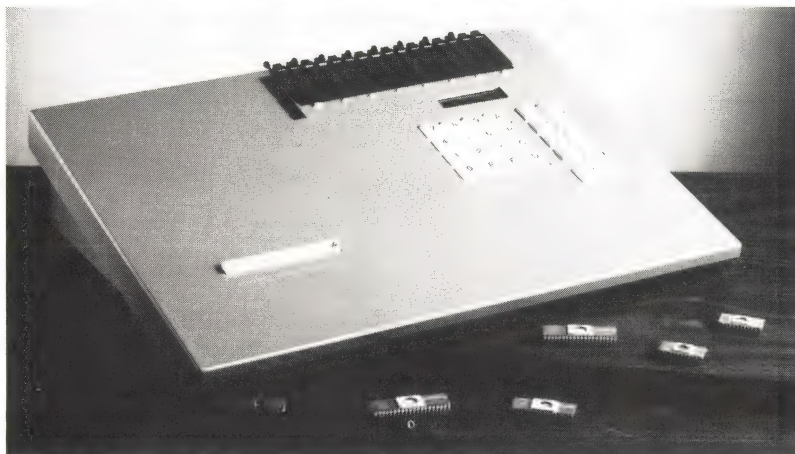
## DATA 6100: The one system that measures up.

Whatever your requirements for high speed waveform analysis or high resolution signal processing—on the lab bench or the factory floor, or in specialized defense applications—the uniquely capable DATA 6100 can measure up. Circle reader service card or call toll free today 1-800-343-8150 (In Mass. call 246-1600).

**ANALOGIC**

**DATA PRECISION**

# BYTEK's NEW 135 MULTIPROGRAMMER™ OFFERS 18/12 PROTECTION PLAN



## THREE PROGRAMMERS IN ONE.

With the addition of the 135 MultiProgrammer™ BYTEK has provided a true Universal Programming Site. The 135 is a SET EPROM Programmer, a GANG EPROM Duplicator, and a UNIVERSAL DEVICE Programmer, designed for Engineering Development, Production and Field Service Environments.

**BYTEK's new 135 MultiProgrammer™** is a High Performance Instrument setting new standards for Universal Device Support and Flexibility at affordable prices.

**VERSATILE:** With standard 256K BYTE of RAM, expandable to 2 MegaByte, the 135 supports more devices than any other production programmer on the market today. The 135 provides EPROM programming capabilities of virtually any 24-, 28-, and 32-Pin EPROM and EEPROM from 16K to MegaBit Devices. The 135 can Program SETS of Devices, 16- and 32-Bit Wide. As a GANG EPROM Duplicator, it copies up to eight (8) devices from RAM, with options for 16 Devices.

**COMPATIBLE:** The 135 offers Terminal and Computer Remote control, Data I/O\* compatible+.

\* Data I/O is a Registered Trademark of Data I/O Corporation.  
+Some limitations may apply.

**FLEXIBLE:** The 135 can easily be expanded to program 40-Pin EPROMS, Bipolar PROMs, Logic Array Devices, EPROM Emulation, and 40 Pin Micro Devices.

**18/12 PROTECTION PLAN:** BYTEK offers High Performance, unsurpassed quality, and product reliability. BYTEK is the first to offer a full EIGHTEEN MONTH WARRANTY, and TWELVE MONTH FREE Device Support Updates.

# BYTEK

Call us today at:  
**1-800-523-1565**  
Mastercard or Visa is accepted  
In Florida call 1-305-994-3520

## BYTEK Corporation

Instrument Systems Division  
1021 S. Rogers Cir., Boca Raton, FL 33487  
Tel: (305) 994-3520 FAX: (305) 994-3615

## BYTEK International

511 11th Ave., So. Minneapolis, MN 55415  
Tel: (612) 375-9517 FAX: (612) 375-9460  
Telex: 4998369 BYTEK

CIRCLE NO 20

# DID YOU KNOW?

EDN serves  
electronic engineers and  
engineering managers in more than  
100 countries worldwide.

# EDN

# 1988

# EDN

## CALENDAR OF ELECTRONICS AND COMPUTER INDUSTRY EVENTS

*Your 12-Month Guide to  
What's Happening Where*

Here it is . . . your own removable, comprehensive guide to national and international conventions, conferences, seminars, meetings, and exhibits in the electronics field.

Just tear the Calendar out and tack it up. That way you'll have this valuable reference source right at your fingertips all year long. We've included an inquiry reply card for your convenience in requesting information from any of the companies featured.

# EDN 1988 CALENDAR

A Guide to Electronics and Computer Industry Events



When your eyes need high quality displays,  
you need the Toshiba ST LCD.

**TOSHIBA**

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
					1  NEW YEAR'S DAY	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17  MARTIN LUTHER KING, JR. DAY	18	19	20	21	22	23
24 31	25	26	27	28	29	30

**•5-8 21st Hawaii International Conference on System Sciences**

Kona Surf Resort, Kailu-Kona (Ralph Sprague, Jr., Decision Sciences Dept., University of Hawaii, 2404 Maile Way, E-303, Honolulu, HI 96822, 808/948-7430)

**•7-8 Simulation in Engineering Education**

San Diego (SCS, P.O. Box 17900, San Diego, CA 92117, 619/277-3888)

**•7 OEM Peripheral Conference**

Hilton Towers, Irvine (Susie Ring, ICC, 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

**•10 3rd Annual Technical Symposium on Optoelectronics & Laser Applications in Science & Engineering**

Viscount Hotel, Los Angeles (Jane Lybecker, SPIE, P.O. Box 10, Bellingham, WA 98227, 206/676-3290)

**•12 PC Reseller Conference**

Hilton International, London (Susie Ring, ICC, 3151 Airway Avenue, #C-2, Costa Mesa, CA, 92626, 714/957-0171)

**•12-14 ATE & Instrumentation Conference West**

Disneyland Hotel, Anaheim (MG Expositions Group, 1050 Commonwealth Avenue, Boston, MA 02215, 800/223-7126)

**•13-15 Annual IEEE Design Automation Workshop**

Gold Canyon Ranch, Apache Junction, Arizona (Walling Cyre, Control Data, HQM 173, Box 1249, Minneapolis, MN 55440, 612/853-2692)

**•13-15 Computer Graphics '88**

U.S. Grant Hotel, San Diego (Carol Every, Frost & Sullivan, Inc., 106 Fulton Street, New York, NY 10038, 212/233-1080)

**•14 OEM Peripheral Conference**

Sheraton, Munich (Susie Ring, ICC, 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

**•19 PC Reseller Conference**

Hotel International, Zurich (Susie Ring, ICC, 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

**•19-21 Failure Avoidance/Failure Analysis For VLSI Circuits**

Santa Clara (DM Data Inc., 6900 E. Camelback Rd., Suite 1000, Scottsdale, AZ 85251, 602/945-9620)

**•19-21 PCB Expo 1988**

Omni International Hotel, Orlando (Heidi Hogarth, 1790 Hembree Road, Alpharetta, GA 30201, 404/475-1818)

**•20 Basic IC Technology Seminar**

San Jose (ICE 15022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

**•20-21 San Diego Electronics Show**

Del Mar Fairgrounds, Del Mar, CA (Harry Schwartz, Epic Enterprises, Inc., 3838 Camino Del Rio North, Suite 164, San Diego, CA 92108, 619/284-9268)

**•21 OEM Peripheral Conference**

Hotel Executive, Milano (Susie Ring, ICC, 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

**•21 Status '88**

San Jose (ICE 105022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

**•22 How to Save Thousands of Dollars on Your Semiconductor Purchases and System Designs**

Santa Clara (DM Data Inc., 6900 E. Camelback Rd., Suite 1000, Scottsdale, AZ 85251, 602/945-9620)

**•24-27 Workshop on High-Level Synthesis**

Rosario Resort, Orcas Island, Eastsound, WA (Ewald Detjens, Exemplar Logic, 1820 Carleton Street, Berkeley, CA 94703, 415/849-2020)

**•25-26 Engineers Expo Career Open House**

Melbourne/Orlando, FL (Engineers Expo, 2367 Auburn Avenue, Cincinnati, OH 45219, 513/721-3030)

**•25-27 Conference On Optical Fiber Communication (OFC '88)**

New Orleans (OSA Meetings Department, 1816 Jefferson Place, NW, Washington DC 20036, 202/223-0926)

**•25-28 Tenth Annual Communications Networks Conference and Exposition**

Washington Convention Center, Washington DC (Nancy Thayer, IDG Conference Management Group, P.O. Box 9171, Cochituate Road, Framingham, MA 01701, 617/879-0700)

**•25-28 88th Annual Florida Computing Conference**

Hyatt Orlando, Kissimmee, FL (David L. Brittain, Florida Department of Education, Knott Bldg., Tallahassee, FL 32399, 904/488-0980)

**•26 OEM Peripheral Conference**

Marina Marriott Hotel, Ft. Lauderdale (Susie Ring, ICC 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

**•26 OEM Peripheral Conference**

Hotel Paris Sofitel, Paris (Susie Ring, ICC 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

**•26-28 1988 Annual Reliability and Maintainability Symposium**

Biltmore Hotel, Los Angeles (V. R. Monshaw, RCA, Astro Electronics, P.O. Box 800, MS 55, Princeton, NJ 08540, 609/426-2182)

**•26-28 AFCEA West '88**

Disneyland Hotel, Anaheim (AFCEA International Headquarters, 4400 Fair Lakes Court, Fairfax, VA 22033, 703/631-6125)

**•26-28 Charlotte Manufacturing Productivity Conference & Advanced Productivity Exposition (APEX)**

Charlotte Convention Center, Charlotte, NC (Nancy LePage, Society of Manufacturing Engineers, One SME Drive, PO Box 930, Dearborn, MI 48121, 313/271-0777)

**•27-30 Expo Hospital**

Nikko Hotel, Mexico City (Bill Warnes, Marketing International Corp., P.O. Box 4749, Arlington, VA 22204, 703/685-0600)

**•27 Basic IC Technology**

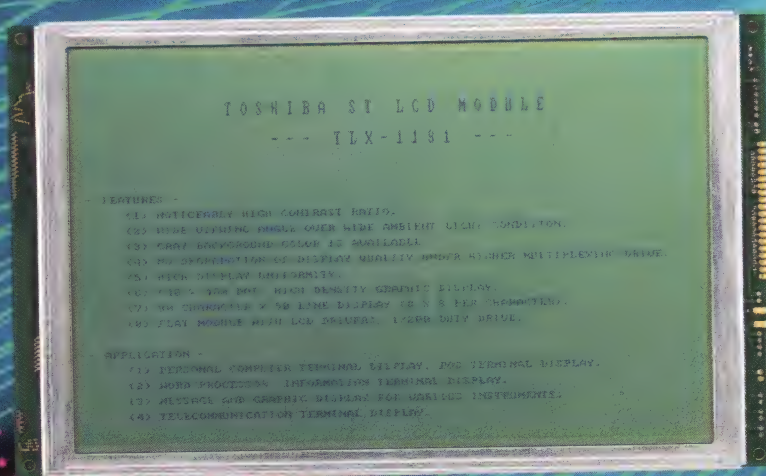
Scottsdale, AZ (ICE, 15022 N. 75th Street Scottsdale, AZ 85260, 602/998-9780)

**•28 Status '88**

Scottsdale, AZ (ICE, 15022 N. 75th Street Scottsdale, AZ 85260, 602/998-9780)

**•31-Feb. 5 1988 Power Engineering Society Winter Meeting**

Penta Hotel, New York (J.G. Derse, 1030 Country Club Road, Bedminster, NJ 07921, 201/725-4388)



# When your eyes need high quality displays, you need the Toshiba ST LCD.

Once again Toshiba has made a breakthrough in display quality. Clear and beautiful displays are achieved with the ST LCD. The LCD for the new age. And for your eyes. Now, by employing a new operating mode, this module provides excellent readability from a viewing angle perpendicular to the LCD panel. This was difficult to achieve with conventional LCDs. The aim was to make our LCD easier on the eyes. We succeeded with the ST LCD. Just another improvement in the man-to-machine interface by Toshiba.

## ST LCD Module Specifications

Model name	Number of dots	Duty	Dot pitch (mm)	Outline dimensions (mm)	EL Back Light (Option)	Recommended controller
TLX-1181*	640 × 400	1/200	0.35 × 0.35	276 × 168 × 12	Yes	T7779
TLX-932	640 × 200	1/200	0.375 × 0.375	293 × 97.6 × 14	No	T7779
TLX-561	640 × 200	1/200	0.35 × 0.49	275 × 126 × 14	Yes	T7779
TLX-711A*	240 × 64	1/64	0.53 × 0.53	180 × 65 × 12	Yes	T6963C**
TLX-341AK*	128 × 128	1/64	0.45 × 0.45	93.2 × 86.6 × 12	No	T6963C

\*Under development, \*\*Built-in controller

In Touch with Tomorrow  
**TOSHIBA**

Toshiba America, Inc., Chicago Office: 1101A Lake Cook Rd., Deerfield, IL 60015 Tel: 312-945-1500 Western Area Office: 2021 The Alameda, Suite 220, San Jose, CA 95126 Tel: 408-244-4070 Eastern Area Office: 67 South Bedford Street, Suite 200W, Burlington, MA 01803 Tel: 617-272-4352, 5548

CIRCLE NO 51

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
	1	2	3	4	5	6
7	8 WASHINGTON'S BIRTHDAY obsvd.	9	10 ASH WEDNESDAY	11	12 LINCOLN'S BIRTHDAY	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29					

## •1-5 4th International Conference on Data Engineering

Airport Hilton, Los Angeles (Benjamin W. Wah, Dept. of Elec. & Comp. Engineering, University of Illinois, Urbana, IL 61801, 217/333-3516)

## •1-5 APEC '88 IEEE Applied Power Electronics Conference and Exposition

Fairmont Hotel, New Orleans (William W. Burns, III, Conference Chairman, Data General Corporation, E213 4400 Computer Drive, Westboro, MA 01580, 617/870-9182)

## •3 Basic IC Technology

Orlando, FL (ICE, 15022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

## •3-5 1988 SCS Multiconference: Modeling and Simulation on Microcomputers, Power Plant Simulation, Aerospace Simulation, Distributed Simulation, AI and Simulation, Multiprocessor and Array Processor Conference

San Diego, CA (SCS, P.O. Box 17900, San Diego, CA 92117, 619/277-3888)

## •4 Status '88

Orlando (ICE, 15022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

## •4 Computer Graphic Conference

Red Lion Inn, San Jose (Susie Ring, Conference Coordinator, ICC, 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

## •9-12 Mexico ComExpo 88

National Auditorium, Mexico City (Bill Warnes, Marketing International Corp., P.O. Box 4749, Arlington, VA 22204, 703/685-0600)

## •10 Basic IC Technology

Newport Beach, CA (ICE, 15022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

## •11 OEM Peripheral Conference

Crowne Plaza Hotel, Dallas (Susie Ring, ICC, 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

## •11 Status '88

Newport Beach, CA (ICE, 15022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

## •16 ERA Communications Trade Fair

Mesa/Chandler Holiday Inn, Mesa AZ (Robert Myers, 1700 Westwood Blvd., Suite 101, Los Angeles, CA 90024, 213/879-7119)

## •17 Basic IC Technology

Boston (ICE, 15022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

## •17-19 IEEE International Solid-State Circuits Conference

San Francisco (Lewis Winner, 301 Almeria Avenue, Coral Gables, FL 33134, 305/446-8193/4)

## •18 ERA Communications Trade Fair

Town & Country Hotel, San Diego (Robert Myers, 1700 Westwood Blvd., Suite 101, Los Angeles, CA 90024, 213/879-7119)

## •18 IEEE Video Conferences: User Examples of AI

(IEEE Continuing Education Dept., 445 Hoes Lane, Piscataway, NJ 08854, 201/981-0060 ext. 412)

## •22-23 Engineers Expo Career Open House

Baltimore/Washington Corridor (Engineers Expo, 2367 Auburn Avenue, Cincinnati, OH 45219, 513/721-3030)

## •22-24 PCB Expo 1988

Red Lion Inn, Costa Mesa, CA (Heidi Hogarth, 1790 Hembree Road, Alpharetta, GA 30201, 404/475-1818)

## •23-25 Buscon/88-West

Disneyland Hotel, Anaheim (Anne Weber, MultiDynamics, Inc., 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701, 213/402-1618)

## •23-25 Nepcon West '88

Anaheim Convention Center, Anaheim (Jerry Carter, Cahners Exposition Group, 1350 E. Touhy Avenue, Des Plaines, IL 60018, 312/299-9311)

## •23-25 Power Electronics '88 West

Disneyland Hotel, Anaheim (Anne Weber, MultiDynamics, Inc., 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701, 213/402-1618)

## •23-25 Advanced Ceramics '88 Conference & Tabletop Exhibits

Hyatt Regency, Rosemont, IL (Nancy LePage, Society of Manufacturing Engineers, One SME Drive, PO Box 930, Dearborn, MI 48121, 313/271-0777)

## •25 PC Reseller Conference

Ramada Hotel O'Hare, Chicago (Susie Ring, ICC, 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

## •25-26 Automated Manufacturing '88: Computers, Communications and Controls in the Factory

Don Cesar Beach Resort, St. Petersburg Beach, FL (Yvonne Chism, Frost & Sullivan, Inc., 106 Fulton Street, New York, NY 10038, 212/233-1080)

## •28-March 2 1988 IEEE Network Operations and Management Symposium

Sheraton New Orleans Hotel, New Orleans (Dr. R. Bruce Kiebert, AT&T Bell Laboratories, Room 14A-471, Whippany Road, Whippany, NJ 07981, 201/386-5371)

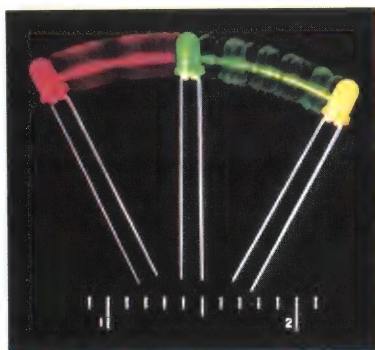
## •29-March 3 1988 IEEE Computer Society COMPCON Spring '88

Cathedral Hill Hotel, San Francisco (COMPCON Spring '88, 1730 Massachusetts Avenue NW, Washington, DC 20036, 202/371-0101)



# FLASH OF BRILLIANCE

Tri-Color Excellence in a T1 size from the World Leader in High-Efficiency LEDs.



Actual size

For performance superiority, space saving design and packaging selection, Data Display's tri-color LEDs are your brilliant choice. As high-intensity red, green and amber light indicators, their quality and reliability clearly shine through in a T1 package.

The tri-color LED light output is a good 21 MCD with wavelengths of 635 for red and 565 green. A milky diffused package provides an extra wide viewing angle. Also, you're designing in the dependability and competitive pricing you can expect from a world leader in LEDs.

## Save Space. Two LEDs in One Package.

All of our tri-color LEDs use a bright idea to improve your high density packing. The T1 size has 2 LED chips in the same small package. Two-terminal operation gives red (DC +), green (DC -), and amber (AC) with current of 20mA.

Also having the same two-terminal operation features is a larger T1 $\frac{3}{4}$  size. It's ideal for lens illumination. Another T1 $\frac{3}{4}$  size has three-terminal operation with a common cathode.

## Choice of Packages. Shining Support.

Data Display has a network of sales representatives and distributors to get you the quantities you want. Our complete line of LEDs includes a variety of packaging options—from PCB mounts including our new variable array to panel lights available with or without lenses. And we also provide engineering support.

Make the brilliant choice. Call Data Display, TOLL FREE (800) 421-6815. Within California, call (213) 640-0442. Free catalog.



*Your Brilliant Choice*

P.O. Box 91072, Los Angeles, CA 90009  
(213) 640-0442, TELEX 664-690, FAX 213-640-7639

**INTERNATIONAL REPS:** Argentina YEL SRL, PH: 541 46 2211, TLX: 390 18605 - Australia Ampec, PH: 6893522, TLX: 790 127136 AMPEC, FAX: 612 6335448 - Belgium/Holland Klaasing Etc, PH: 01620 81600, TLX: 844 54598 KLBDNL, FAX: 0162056500 - Denmark Radio Parts, PH: 01 333311, TLX: 855 19613 RPARTDK - France A Jahnichen, PH: 387 59 09, TLX: 842290714, FAX: 011311-4387-3319 - Israel R.C.M. Computers, PH: 03 476225, TLX: 922 341390 IL, FAX: 011-972-491942 - Italy Microdata, PH: 0187 988182, TLX: 8432 72070 - South Africa Liberty Elec., PH: 52 7637/8/9, TLX: 960 867325A SA - Spain Betatron, PH: 6942511, TLX: 831 23911 PCOE - United Kingdom Marl Int'l, PH: 0229 52430, TLX: 851 65100 MARLG, FAX: 0229-55155 - West Germany/Austria Kuhn GmbH, PH: 06235 5662, TLX: 841 464766 KUHND, FAX: 0623581955

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17 ST. PATRICK'S DAY	18	19
20	21	22	23	24	25	26
27 PALM SUNDAY	28	29	30	31		

## •1-3 Semicon Europa

Zuspa Convention Center, Zurich (Bill Galarnea, 805 E. Middlefield Road, Mountain View, CA 94043, 415/964-5111)

## •4 Computer Graphic Conference

Sheraton National Hotel, Arlington, VA (Roger J. Martin, U.S. Dept. of Commerce, Natl. Bureau of Standards, Technology Bldg, 225, Rm. B266, Gaithersburg, MD 20899, 301/975-3295)

## •7-10 FOSE '88, FOSE Software, FOSE Computer Graphics

Washington Convention Center, Washington, DC (Jackie Voight, National Trade Association, 800/638-8510, 703/683-8500)

## •7-10 33rd International SAMPE Symposium/Exhibition

Anaheim Convention Center, Anaheim (Marge Smith, SAMPE, 843 West Glentana (Box 2459), Covina, CA 91722, 818/331-0616)

## •8 Semiconductor Packaging

San Jose (ICE, 15022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

## •8-10 Southcon'88

Orange County Convention/Civic Center, Orlando, FL (Alexes Razevech, Electronic Conventions Mgmt., 8110 Airport Blvd., Los Angeles, CA 90045, 800/421-6816, or 213/772-2965)

## •8-11 1988 International Zurich Seminar on Digital Communications

Zurich (Secretariat IZS 88, c/o P. Gunzburger, Hasler AG, TDS, Belpstrasse 23, CH-3000 Bern 14, Switzerland 41-31-632808)

## •9 OEM Peripheral Conference

Red Lion Inn, San Jose (Susie Ring, ICC, 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

## •9-11 Practical IC Fabrication

San Jose (ICE, 15022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

## •14-15 Engineers Expo Career Open House

Huntsville, AL (Engineers Expo, 2367 Auburn Avenue, Cincinnati, OH 45219, 513/721-3030)

## •14-18 4th International Conference on Artificial Intelligence Applications

Sheraton Harbour Island, San Diego (AI Conference, Computer Society of the IEEE, 1730 Massachusetts Avenue, NW, Washington, DC 20036, 202/371-1013)

## •15-17 Failure Avoidance/Failure Analysis for VLSI Circuits

Orlando (DM Data, Inc., Ste 1000, Scottsdale AZ, 85251, 602/945-9620)

## •15-18 PetroMex Petroleum/Petrochemical Equipment Expo

National Auditorium, Mexico City (William Warnes, Marketing International Corp., P.O. Box 4749, Arlington, VA 22204, 703/685-0600)

## •16 ERA CIDtec

Edwards Air Force Base, CA (Bruce Myers, 1700 Westwood Blvd., Suite 101, Los Angeles, CA 90024, 213/879-7119)

## •16-18 Twenty-first Annual Simulation Symposium

Tampa, FL (Alfred Jones, Computer Science Department, Florida Atlantic University, Boca Raton, FL 33431, 305/393-3675)

## •17 ERA CIDtec

China Lake Naval Weapons Center, China Lake, CA (Bruce Myers, 1700 Westwood Blvd., Suite 101, Los Angeles, CA 90024, 213/879-7119)

## •18 How to Save Thousands of Dollars on Your Semiconductor Purchases and System Designs

Orlando (DM Data, Inc., 6900 E. Camelback Rd., Suite 1000, Scottsdale, AZ 85251, 602/945-9620)

## •21-24 Computer Standards Conference (COMPSTAN)

Sheraton National, Arlington, VA (Roger J. Martin, U.S. Dept. of Commerce, Natl. Bureau of Standards, Technology Bldg, 225, Rm. B266, Gaithersburg, MD 20899, 301/975-3295)

## •21-24 Westec '88, The Western Metal & Tool Exposition and Conference

Los Angeles Convention Center, Los Angeles (Nancy LePage, Society of Manufacturing Engineers, One SME Drive, PO Box 930, Dearborn, MI 48121, 313/271-0777)

## •21-24 Video Audio & Data Recording

University of York, England (The Conference Secretariat, Institution of Electronic and Radio Engineers, Savoy Hill House, Savoy Hill, London WC2R OJD, England)

## •21-24 NCGA Computer Graphics '88

Anaheim Convention Center, Anaheim (Nancy A. Flower, National Computer Graphics Association, 2722 Merrilee Drive, Suite 200, Fairfax, VA 22031, 703/698-9600)

## •22-23 Failure Analysis Avoidance

San Jose (ICE, 15022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

## •23 IEEE Video Conferences: VLSI Microprocessors

(IEEE Continuing Education Dept., 445 Hoes Lane, Piscataway, NJ 08854, 201/981-0060 ext. 412)

## •23-25 Conference on Office Information Systems

Hyatt Richeys Hotel, Palo Alto (Robert B. Allen, Room 2A 367, Bell CORE, Morristown, NJ 07960, 201/829-4315)

## •23-25 Extending Database Technology

Cini Foundation, Venice (Prof. Stefano Ceri, Politecnico di Milano, Dipart. de Elektronika, Piazza Leonard da Vinci 32, 20133 Milano, Italy, 02-2367241)

## •24 ERA Electro-tech

Proud Bird Restaurant, Los Angeles (Bruce Myers, 1700 Westwood Blvd., Suite 101, Los Angeles, CA 90024, 213/879-7119)

## •27-April 1 AEA/Wharton School General Management Program

Philadelphia (Mary Horngren Frost, AEA, 5201 Great America Parkway, Santa Clara, CA 95054, 408/987-4200)

## •28 OEM Peripheral Conference

Sheraton Tara Hotel, Nashua, NH (Susie Ring, ICC, 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

## •28-31 IEEE Infocom '88

Sheraton New Orleans Hotel, New Orleans (Infocom '88, Computer Society of the IEEE, 1730 Massachusetts Avenue, NW, Washington, DC 20036, 202/371-1013)

## •28-31 Interface '88

McCormick Place, Chicago (Peter B. Young, Interface Group, 300 First Avenue, Needham, MA 02194, 617/449-6600)

## •28-31 World Congress on Computing

McCormick Place, Chicago (Peter B. Young, Interface Group, 300 First Avenue, Needham, MA 02194, 617/449-6600)

## •29-30 Colour Information Technology

University of Surrey, England (The Conference Secretariat, Institution of Electronic and Radio Engineers, Savoy Hill House, Savoy Hill, London WC2R OJD, England)

## •29-31 Electronic Imaging Conference West

Anaheim Hilton Hotel, Anaheim (MG Expositions Group, 1050 Commonwealth Avenue, Boston, MA 02215, 617/232-EXPO)

# Sometimes, keeping a low profile pays off.

The survival of today's combat helicopter depends on keeping a low profile. Abbott's BC100 triple output, switching DC-DC converter helps the Lynx helicopter achieve this low profile.

The BC100's low 1.875" profile allowed 100 watts to fit into a tight space requirement. At the same time, the Lynx helicopter was able to take advantage of the economy and reliability that come from using a standard product, the BC100.

Because the BC100 meets the requirements of MIL-STD-810C, and MIL-S-901C, the Lynx program's decision to go with Abbott's BC100 will also pay off in extra survivability. Plus the BC100 features low ripple/noise and EMI within the limits of MIL-STD-461B.

For other applications that call for small yet powerful converters, Abbott offers both 100 and 200 watt models. Each available in single and triple configurations. And all with a wide array of options available.

For more information and a copy of our 1988 Military Power Supply Product Guide, call or write today.



Abbott Transistor Laboratories, Inc. Power Supply Division, 2721 S. La Cienega Blvd., Los Angeles, CA 90034 (213) 936-8185. Eastern Office: (201) 461-4411, Southwest Office: (214) 437-0697, London Office: 0737-82-3273.

WHEN RELIABILITY IS IMPERATIVE®

**abbott**

MILITARY POWER SUPPLIES

CIRCLE NO 53



SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
					1  GOOD FRIDAY	2  PASS-OVER
3  EASTER SUNDAY	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

## •4-8 Semicon Shanghai

Shanghai Exhibition Center, Shanghai, China (Bill Galarnea, 805 E. Middlefield, Road, Mountain View, CA 94043, 415/964-5111)

## •6-8 Fabtech East Conference & Exposition

Baltimore Convention Center, Baltimore (Nancy LePage, Society of Manufacturing Engineers, One SME Drive, PO Box 930, Dearborn, MI 48121, 313/271-0777)

## •7-10 West Coast Computer Faire

Moscone Center, San Francisco (Peter B. Young, The Interface Group, 300 First Avenue, Needham, MA 02194, 617/449-6600)

## •8 PC Reseller Conference

Loews Glenpointe Hotel, Teaneck, NJ (Susie Ring, ICC, 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

## •10-13 Southeastcon '88

Hyatt Regency Hotel, Knoxville, TN (Prof. Reece Roth, Dept. of Electrical Engineering, University of Tennessee, Knoxville, TN 37996-2100, 615/974-4446)

## •11-13 4th International Conference on HF Radio Systems & Techniques

Savoy Place, London (IEE Conference Services, Savoy Place, London WC2R OBL, 01-240-1871, ext. 222)

## •11-13 1988 Computer Networking Symposium

Sheraton National Hotel, Arlington, VA (George K. Chang, 6 Corporation Pl., Piscataway, NJ 08854, 201/699-3879)

## •11-14 1988 IEEE International Conference on Acoustics, Speech & Signal Processing (ICASSP '88)

New York Hilton Hotel, New York (Aaron E. Rosenberg, AT&T Bell Laboratories, Room 2D528, 600 Mountain Avenue, Murray Hill, NJ 07974, 201/582-4985)

## •11-14 1988 International Reliability Physics Symposium

Del Monte Hyatt Hotel, Monterey, CA (Alfred L. Tamburrino, RADC/RBRP, Griffiss AFB, NY 13441-5700, 315/330-2813)

## •11-15 10th International Conference on Software Engineering

Raffles City, Singapore (Tan Chin Nam/Lim Swee Say, 71 Science Park, Singapore 0511, 65/772-0200)

## •11-15 Compeuro

Vrije Universiteit, Brussels, Belgium (Jacques Tiberghien, Vrije Universiteit Brussels, Pleinlaan 2, 1050 Brussels, Belgium, 32-2-641-29-05)

## •11-15 International Specialist Seminar on the Design and Application of Parallel Digital Processors

Lisbon, Portugal (IEE Conference Services, Savoy Place, London WC2R OBL, 01-240-1871, ext. 222)

## •12 Semiconductor Packaging

Scottsdale, AZ (ICE, 105022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

## •12-13 MMA Meeting & Show

Sheraton Centre, New York (Jim Mion or Annie Zdinak 333 Sylvan Avenue, Englewood Cliffs, NJ 07632, 800/237-0316, 201/569-6916)

## •13-15 Practical IC Fabrication

Scottsdale, AZ (ICE, 105022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

## •13-15 Control '88

London (IEE Conference Services, Savoy Place, London WC2R OBL, 01-240-1871, ext. 222)

## •14 OEM Peripheral Conference

Toronto Airport Marriott, Toronto (Susie Ring, ICC, 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

## •17-22 IIEPC 31st Annual Meeting

Diplomat Hotel, Hollywood, FL (Virginia Perry, IIEPC, 7380 N. Lincoln, Lincoln Wood, IL 60646 312/677-2850)

## •18-19 Engineers Expo Career Open House

Long Island (Engineers Expo, 2367 Auburn Avenue, Cincinnati, OH 45219, 513/721-3030)

## •18-20 50th Annual American Power Conference

Palmer House, Chicago (Dr. Robert Porter, Illinois Institute of Technology, Chicago, IL 60616, 312/567-3202)

## •18-21 Eastern Simulation Conferences: Simulators V, The Simulation Profession, Tools for the Simulationist, Credibility Assessment, Simulation Languages, AI and Simulation

Orlando, FL (SCS, P.O. Box 17900, San Diego, CA 92117, 619/277-3888)

## •19-22 1988 Instrumentation and Measurement Technology Conference (IMTC '88)

San Diego Princess Hotel, San Diego (Robert Myers, 1700 Westwood Blvd., Suite 101, Los Angeles, CA 90024, 213/475-4571)

## •19-22 11th Annual IEEE Workshop on Design for Testability

Vail, CO (T.W. Williams, IBM Corporation, PO Box 1900, Dept. 67A/021, Boulder, CO 80301-9191, 303/924-7692)

## •19-22 Analytica 88

Munich Trade Fair Centre, Munich (Gerald G. Kallman, Kallman Associates, Five Maple Court, Ridgewood, NJ 07450-4431, 201/652-7070)

## •20-21 1988 IEEE National Radar Conference

University of Michigan, Ann Arbor (Mr. Clarence Heerema, Environmental Research Inst. of Michigan, PO Box 8618, Ann Arbor, MI 48107, or Dr. Jack Walker, (313) 994-1200)

## •24-26 Semicon West

San Mateo Fair Grounds, San Mateo, CA (Bill Galarnea, 805 E. Middlefield, Road, Mountain View, CA 94043, 415/964-5111)

## •24-29 1988 International Conference on Robotics and Automation

Wyndham Franklin Plaza Hotel, Philadelphia (Dr. Theo Pavlidis, Dept. of Electrical Engineering, SUNY, Stony Brook, NY 11794, 516/246-3556 or Prof. R.P. Paul, University of Pennsylvania, Philadelphia, PA 19104, 215/898-1592)

## •25-28 2nd International Conference on Expert Database Systems

Sheraton Premiere Hotel, Tysons Corner, VA (Edgar H. Sibley, George Mason University, ICSE Dept., 4400 University Drive, Fairfax, VA 22030)

## •25-29 Conference on Lasers and Electro-Optics (CLEO'88)

Anaheim (OSA, Meetings Dept., 1816, Jefferson Place NW, Washington, DC 20036 202/223-0926)

## •26 Computer Graphic Conference

Munich Sheraton, Munich (Susie Ring, ICC, 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

## •26-28 Electronic Distribution Conference '88

Las Vegas Hilton, Las Vegas (David Fischer, 222 S. Riverside Plaza, Ste. 2710, Chicago, IL 60606)

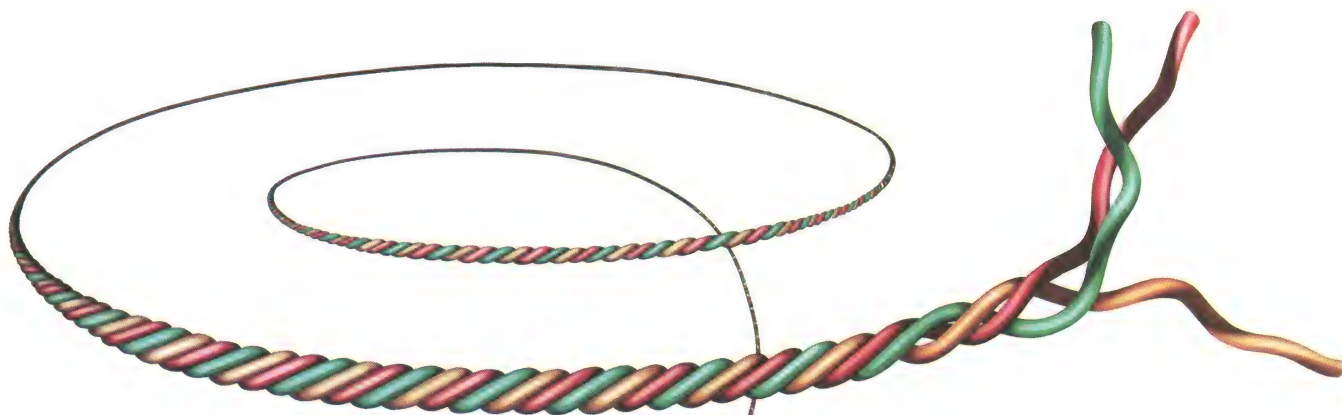
## •26-28 ATE 1988 Automatic Testing and Test Instrumentation

Olympia, London (Network Events, Ltd., Printers Mews, Market Hill, Buckingham, MK18 1JX, UK, 0280 815226)

## •26-28 MILTEST 1988 Military Test Equipment

Olympia, London (Network Events, Ltd., Printers Mews, Market Hill, Buckingham, MK18 1JX, UK, 0280 815226)

# Wind up with a new twist in twisted magnet wire.



## **TWISTITE™**

**Magnet Wire gives you superior performance and tighter control over twisted wire construction.** If you use twisted magnet wire in the production of custom toroid, ferrite or recording head coils, specialty audio and R.F. transformers, you'll be glad to discover TWISTITE Magnet Wire from MWS.

### **Only TWISTITE offers these advantages.**

Because TWISTITE is custom produced by MWS, you get a wider range of twisting constructions. Manufacturing capabilities include:

- Up to 33 Twists Per Inch on fine wire.
- Twisting tolerance as tight as  $\pm 1\%$ .
- Tightly controlled capacitance, inductance and impedance characteristics.
- Up to 10 colors in some sizes for conductor identification.
- Huge selection of insulations: NEMA MW 1000, JW1177 105-220°C (single thru quadruple film builds).
- Wide range of sizes: 24AWG and finer.

- Wide variety of conductor materials: copper, silver, plated conductors and special alloys.

### **Discover MWS today.**

Call or write for your FREE copy of the new MWS Technical Data Booklet. It's filled with useful information on all wire products produced and inventoried by MWS. You'll discover why MWS is the industry leader in specialty wire products. Samples of TWISTITE Magnet Wire are available upon request.

# **MWS®**

## **Wire Industries**

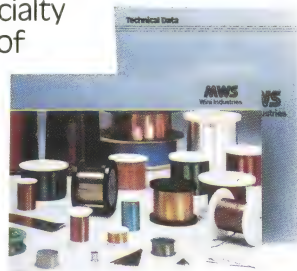
31200 Cedar Valley Drive, Westlake Village CA 91362

**CALL TOLL FREE 800 423-5097**

In California 800-992-8553.

In Los Angeles 818-991-8553

TWISTITE™ is a trademark of MWS Wire Industries



**CIRCLE NO 54**

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30 MEMORIAL DAY	31				

**-2-5 SME 1988 Cleveland International Conference and Exposition**

Cleveland Convention Center, Cleveland (Nancy LePage, Society of Manufacturing Engineers, One SME Drive, PO Box 930, Dearborn, MI 48121, 313/271-1500)

**-2-5 1988 IEEE IAS Industrial & Commercial Power Systems Conference (I&CPS '88)**

Baltimore Marriott Inner Harbor, Baltimore (Philip Hickman, El Comm Sales Associates, 1428 Meridene Drive, Baltimore, MD, 301/532-7565)

**-3-5 Electronic Displays (ED88 Paris)**

Palais des Congres, Paris (Network Events, Ltd., Printers Mews, Market Hill, Buckingham MK18 1JX, England, 0280 815226)

**-4 Computer Graphic Conference**

Hilton International, London (Susie Ring, 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

**-4 IEEE Videoconferences: Solid State Lasers**

IEEE Continuing Education Dept., 445 Hoes Lane, Piscataway, NJ 08854-4150, 201/981-0060 ext. 412)

**-4-5 Midwest Electronics Exposition**

St. Paul Civic Center, St. Paul (MG Expositions Group, 1050 Commonwealth Avenue, Boston, MA 02215, 617/232-EXPO)

**-4-6 The Artificial Intelligence and Advanced Computer Technology Conference/Exhibition**

Long Beach, CA (Dr. Murray Teitell, Intelligent Choice, 1050 Duncan Ave., Ste. D, Manhattan Beach, CA 91109, 213/379-9680)

**-4-6 Symposium AFCEA Exposition: Cooperation in C3I**

Le Palais des Congres and Hotel Concorde La Fayette, Paris (John Spargo and Associates, 4400 Fair Lakes Court, Fairfax, VA 22033-3899, 703/631-6200)

**-9-11 1988 38th Electronic Components Conference (ECC)**

Biltmore Hotel, Los Angeles (Ron W. Gedney, Dept. T-10-B32-2, IBM Corp., 1701 North Street, Endicott, NY 13760, 607/755-3046)

**-9-12 Comdex/Spring '88**

Georgia World Congress Center, Atlanta (Peter B. Young, The Interface Group, 300 First Avenue, Needham, MA 02914, 617/449-4200)

**-10 Computer Graphic Conference**

Hilton International Paris, Paris (Susie Ring, 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

**-10-11 Failure Analysis Avoidance**

Boston (ICE, 15022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

**-10-12 Electro '88**

World Trade Center and Bayside Exposition Center, Boston (Alexis Razevech, Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045, 213/772-2965)

**-11-12 WESCANEX '88 Digital Communications: Fibre, Satellite, Networks**

University of Saskatchewan, Saskatoon, Saskatchewan, Canada (Don Barnett, Canadian Centre for Advance Instrumentation, 15, Innovation Blvd., Saskatoon, Saskatchewan, Canada, S7N 2X8)

**-12-13 5th Workshop on Real-Time Operating Systems**

Omni Shoreham Hotel, Washington, DC (Prof. John A. Stankovic, Dept. of Computer & Info Science, University of Massachusetts, Amherst, MA 01003, 413/545-0720)

**-16 PC Reseller**

Hilton International, London (Susie Ring, 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

**-16-19 1988 Custom Integrated Circuits Conference (CICC '88)**

Rochester Riverside Convention Center, Rochester, NY (Laura Silzars, Convention Coordinating, 6900 SW Canyon Drive, Portland, OR 97225, 503/292-6347)

**-17-19 PCB Expo**

Red Lion Inn, San Jose (Heidi Hogarth, 1790 Hembree Road, Alpharetta, GA 30201, 404/475-1818)

**-17-19 Failure Avoidance/Failure Analysis for VLSI Circuits**

Boston (DM Data, Inc., 6900 E. Camelback Road, Suite 1000, Scottsdale, AZ 85251, 602/945-9620)

**-18-21 AEA Executive Marketing Forum**

Monterey, CA (Susan Puleo, AEA, 5201 Great America Parkway, Santa Clara, CA 95054, 408/987-4251)

**-20 How to Save Thousands of Dollars on Your Semiconductor Purchases and System Designs**

Boston (DM Data, Inc., 6900 E. Camelback Road, Suite 1000, Scottsdale, AZ 85251, 602/945-9620)

**-20-22 RAINBOWfest**

Hyatt Regency Woodfield, Schaumburg (O'Hare), IL (Ira D. Barsky, The Falsoft Building, 9509 U.S. Highway 42, PO Box 385, Prospect, KY 40059, 502/228-4492)

**-23-26 Autocom Conference & Exhibits**

Westin Hotel, Detroit (Nancy LePage, Society of Manufacturing Engineers, One SME Drive, PO Box 930, Dearborn, MI 48121, 313/271-1500)

**-23-26 Supercomm '88**

Georgia World Congress Center, Atlanta (Donald R. Pollock, U. S. Telecommunications Suppliers Association, 150 N. Michigan Avenue, Suite 600, IL 60601-7524, 312/782-8597)

**-23-26 3rd International Conference on Ada Applications and Environments**

Sheraton-Wayfarer Inn, Manchester, MA (Derek S. Morris, Dept. of EECS, Stevens Institute of Technology, Hoboken, NJ 07730, 201/420-5606)

**-24-25 Engineers Expo Career Open House**

Dayton, OH/NAECON (Engineers Expo, 2367 Auburn Avenue, Cincinnati, OH 45219, 513/721-3030)

**-24-26 Hartford/Springfield Manufacturing Productivity Conference & Advanced Productivity Exposition (APEX)**

Eastern States Exposition Center, West Springfield, MA (Nancy LePage, Society of Manufacturing Engineers, One SME Drive, PO Box 930, Dearborn, MI 48121, 313/271-1500)

**-24-26 18th International Symposium on Multiple-Valued Logic**

Hotel Saratoga, Madrid (Enric Trillas, Consejo Superior, Investigaciones, Cientificas, Serrano 117, 28006-Madrid, Spain, (91) 6216264)

**-24-27 ComExpo International Computer/Communications Expo**

Venezuela Hilton Hotel, Caracas (William Warnes, Marketing International, PO Box 4749, Arlington, VA 22204 703/685-0600)

**25-27 1988 IEEE MTT-S International Microwave Symposium**

Marriott Marquis/New York Convention Center, New York (Charles Buntschuh, Narda Microwave Corp., 435 Moreland Space Center, Hauppauge, NY 11788, 516/231-1700)

**-25-27 1988 International Workshop on Artificial Intelligence for Industrial Applications**

Hitachi, Japan (Dr. Kotaro Hirasawa, Hitachi Research Laboratory, Hitachi, Ltd., 4026, Kuji-cho, Hitachi, Ibaraki, 319-12 Japan, or Prof. Alfred C. Weaver, Flight Data Systems, EH4, NASA - Johnson Space Center, Houston, TX 77058, 713/483-2801)

**-29-31 1988 18th International Symposium on Multiple Valued Logic**

Palma de Mallorca, Spain (Mr. Enric Trillas, Consejo Superior de Investigaciones, Cientificas, Serrano 17, 28008-Madrid, Spain)

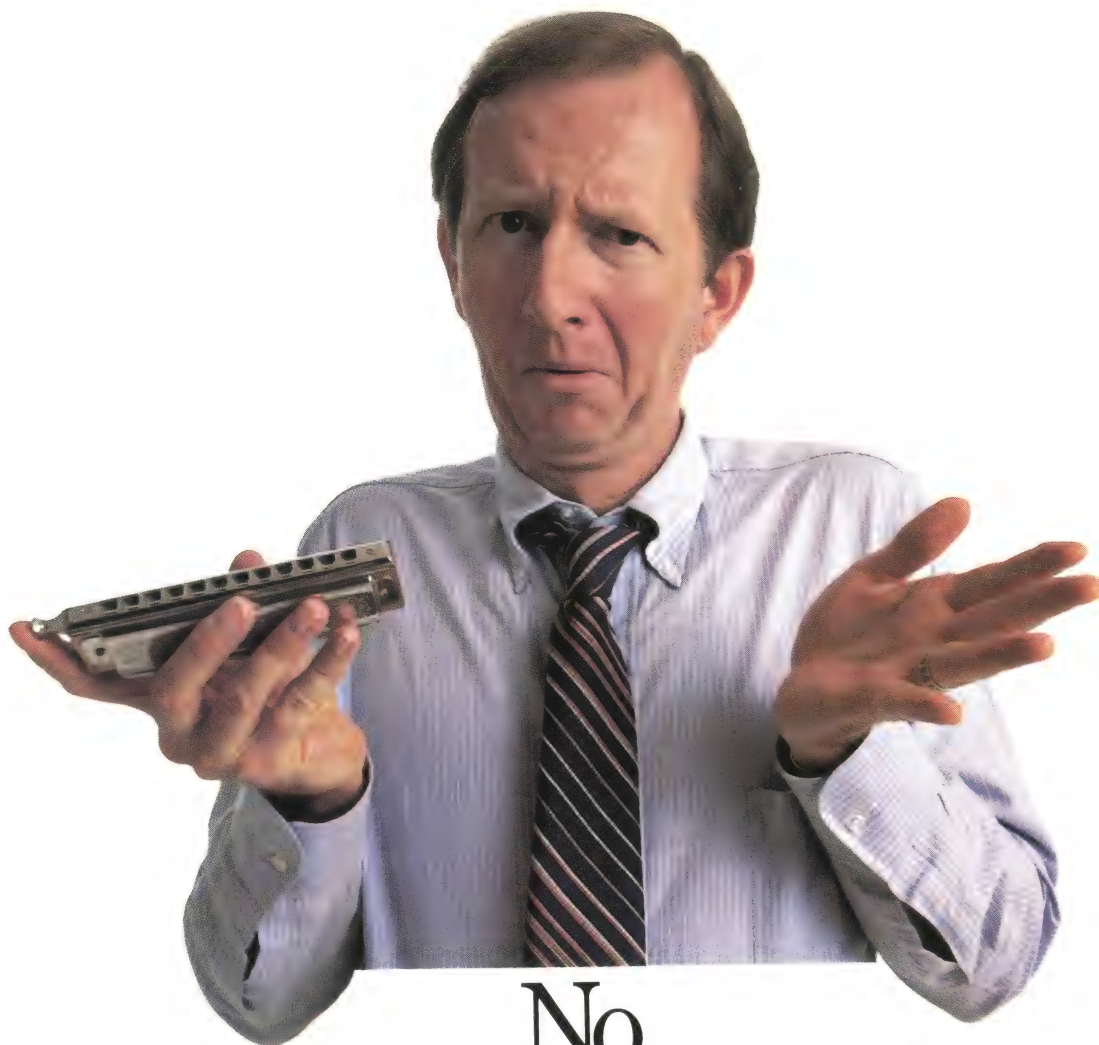
**-30-June 2 15th International Symposium on Computer Architecture**

Honolulu (H. J. Siegel, Supercomputing Research Ctr., 4380 Forbes Blvd., Lanham, MD 20706, 301/731-3700)

**-31-June 3 National Computer Conference NCC/NCE**

Los Angeles Convention Center (Matricia Smith, ISA Services, Inc., P.O. Box 12277, Research Triangle Park, NC 27709, 919/549-8411)

# You've made power supplies smaller, lighter and quieter with a harmonica?



## No, Harmonic Resonance!

Harmonic resonant, as a technology for our new line of power supplies, is practically as significant as going from linear to switching.

So, why did we develop it? It lets us make open frame switchers almost half the size of industry standards. Therefore, lighter. And quieter from a conductive noise standpoint. All for the same price you're paying now.

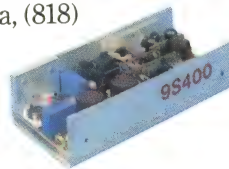
Of course, like all our power supplies introduced since 1983, this new 9S Harmonic Resonant line meets VDE, UL and CSA for safety. And VDE, FCC and IEC for conducted noise.

For more information on our new 9S Harmonic Resonant line (or where to get a nice harmonica), contact us today. Sierra Power Systems (formerly Sierracin), 20500 Plummer Street, Chatsworth, California 91311. Call toll-free (800) 423-5569. In California, (818) 998-9873.



**Sierra Power Systems**

Division of Valor Electronics, Inc.



---

# V25: the most powerful 16-bit single-chip



*Yukio Maehashi  
Manager  
Microcomputer Division.*

microcomputer.

"My masterpiece!"

**NEC**

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
			1	2	3	4
5	6	7	8	9	10	11
12	13	14 FLAG DAY	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

**-4-3 Pacific Northwest Advanced Productivity Exposition (APEX)**

Tacoma Dome, Tacoma, WA (Nancy LePage, Society of Manufacturing Engineers, One SME Drive, PO Box 930, Dearborn, MI 48121, 313/271-1500)

**-1-3 42nd Annual Frequency Control Symposium**

Stouffer Harborplace Hotel, Baltimore (Frequency Control Symposium, PO Box 826, Belmar, NJ 07719)

**-2-3 1st International Conference on Industrial & Engineering and Applications of Artificial Intelligence and Expert Systems**

University of Tennessee Space Institute (Richard Roberters, University of Tennessee Space Institute, Tullahoma, TN 37388, 615/455-0631)

**-5-9 IEEE Computer Society Conference on Computer Vision & Pattern Recognition**

University of Michigan Campus, Ann Arbor (Ramesh Jain, Dept. of EECS, 3215 EECS Bldg, University of Michigan, Ann Arbor, MI 48109-2122, 313/763-0387)

**-5-9 Human Factors and Power Plants Conference**

Doubletree Inn at Fisherman's Wharf, Monterey, CA (H. E. Price, Essex Corp., 333 N. Fairfax Street, Alexandria, VA 22314, 703/548-4500)

**-6-10 1988 IEEE IAS Pulp & Paper Industry Technical Conference**

Hyatt Regency, Milwaukee (David T. Rollay, Conference Chairman, Allen-Bradley Co., 1201 South 2nd Street, Milwaukee, WI 53204, 414/382-2163)

**-6-10 1988 AP-S International Symposium and URSI/USNC Radio Science Meeting**

Sheraton University Inn and Conference Center, Syracuse (Prof. A. T. Adams, Chairman, Syracuse University, 111 Link Hall, Syracuse, NY 13210, 315/423-4397)

**-7-8 Installation Engineering: Designing & Maintaining Successful Systems**

Savoy Place, London (IEE Conference Services, Savoy Place, London, WC2R 0BL, 01-240 1871 ext. 222)

**-7-9 1988 International Symposium on Circuits and Systems (ISCAS '88)**

Helsinki University of Technology, Espoo Finland (Dr. Olli Simula, Helsinki University of Technology, Dept. of Technical Physics, SF-02150 Espoo 15, Finland or Dr. Markku Renfors, Secretary Tampere University of Tech., PO Box 527, SF-33101 Tampere, Finland, +358 31 162696)

**-7-9 ATE & Instrumentation Conference East**

World Trade Center, Boston (MG Expositions Group, 1050 Commonwealth Avenue, Boston, MA 02215, 617/232-EXPO)

**-7-9 Silicon Mountain Symposium**

Colorado Springs (Jil Goebel, Colorado Springs MARCOM Network, PO Box 49014, Colorado Springs, CO 80949-9014, 303/576-7140)

**-8-10 Caribbean ExpoCom**

Caribe Hilton, San Juan, Puerto Rico (William Warens, LATCOM, PO Box 4749, Arlington, VA 22204)

**-8-10 Symposium on the Engineering of Computer Based Medical Systems**

Hyatt Regency Hotel, Minneapolis (John M. Long, Ed. D., 2829 University Avenue SE, Suite 408, Minneapolis, MN 55414, 612/627-4850)

**-8-11 Communic Asia/Infotech Asia 88**

World Trade Centre, Singapore (Gerald G. Kallman, Kallman Associates, Five Maple Court, Ridgewood, NJ 07450-4431, 201/652-7070)

**-8-16 ACM/IEEE Design Automation Conference**

Anaheim Convention Center, Anaheim (Design Automation Conference, PO Pistilli, MP Associates, 7366 Old Mill Trail, Boulder, CO 80301, 303/530-4562)

**-12-15 Design Automation Conference**

Anaheim Convention Center, Anaheim (MP & Associates, 7490 Clubhouse Rd., Suite 102, Boulder, CO 80301, 303/530-4333)

**-12-15 1988 International Conference on Communications (ICC '88)**

Wyndham Franklin Plaza Hotel, Philadelphia (G. William Ruhl, Bell Pennsylvania, 8th floor, 210 Pine Street, Harrisburg, PA 17101, 717/255-8643)

**-12-18 1988 American Control Conference**

Atlanta Hilton & Towers, Atlanta (Judy Book, General Chairman, 1373 Emory Road, Atlanta, GA 30306)

**-13-14 Engineers Expo Career Open House**

Albuquerque, NM (Engineers Expo, 2367 Auburn Avenue, Cincinnati, OH 45219, 513/721-3030)

**-13-17 8th International Conference on Distributed Computing Systems**

Fairmont Hotel, San Francisco (8ICDCS, Computer Society of the IEEE, 1730 Massachusetts Ave NW, Washington, DC 20036-1903, 202/371-1013)

**-13-18 EP China '88**

China International Exhibition Centre, Beijing, P.R.C. (Gerald G. Kallman, Kallman Associates, Five Maple Court, Ridgewood, NJ 07450-4431, 201/652-7070)

**-14-16 2nd SAMPE Electronics Materials Processes Conference**

Red Lion Inn, Seattle, Washington (Marge Smith, SAMPE, International Business Office, 843 West Glentana (Box 2459), Covina, CA 91722, 818/331-0616)

**-14-16 NEPCON East 1988**

Bayside Expo Center, Boston (Janet Schafer, Cahners Exposition Group, Cahners Plaza, 1350 E. Touhy Avenue, PO Box 5060, Des Plaines, IL 60018, 312/299-9311)

**-15-17 1988 Vehicular Technology Conference**

Holiday Inn-Center City, Philadelphia (John Galanti, Conference Chairman, Bell Atlantic Mobile Systems, 180 Mount Airy Road, Basking Ridge, NJ 07920, 201/953-2212, or Robert T. Swint, Arrangements Chairman, Bell of Pennsylvania, 215/466-3284)

**-19-24 1988 International Symposium on Information Theory**

International Conference Center, Kobe, Japan (Prof. Toshihiko Namekawa, Dept. of Communication Engr., Osaka University, 2-1, Yamada-Oka Suita, Osaka 565 Japan or Daniel J. Costello, Jr., Dept. of Electrical Engr., University of Notre Dame, Notre Dame, IN 46556, 219/239-7703)

**-21-23 International Conference on Private Switching Systems and Networks**

Savoy Place, London (IEE Conference Services, Savoy Place, London, WC2R 0BL, 01-240 1871 ext. 222)

**-21-23 PC Expo**

Jacob K. Javits Convention Center, New York (Jim Mion or Annie Zdinak, 333 Sylvan Avenue, Englewood Cliffs, NJ 07632, 800/922-0324, 201/569-8542)

**-21-23 Failure Avoidance/Failure Analysis for VLSI Circuits**

Minneapolis (DM Data Inc., 6900 E. Camelback Rd., Suite 1000, Scottsdale, AZ 85251, 602/945-9620)

**-24 How to Save Thousands of Dollars on Your Semiconductor Purchases and System Designs**

Minneapolis (DM Data Inc., 6900 E. Camelback Rd., Suite 1000, Scottsdale, AZ 85251, 602/945-9620)

**-27-28 Engineers Expo Career Open House**

Cleveland/Akron/Canton (Engineers Expo, 2367 Auburn Avenue, Cincinnati, OH 45219, 513/721-3030)

**-27-30 18th International Symposium on Fault-Tolerant Computing**

Keio Plaza Hotel, Tokyo (Yasuo Komamiya, 2-4-8 Kikuna, Kohoku-ku, Yokohama 222, Japan, 044-911-8181)

**-27-30 5th International Conference on Dielectric Materials, Measurements & Applications**

University of Kent at Canterbury, England (IEE Conference Services, Savoy Place, London WC2R 0BL, 1-240 1871 ext. 222)

**-30-July 2 Semicon Osaka**

The Intex Center, Osaka, Japan (Bill Galarnea, Semiconductor Equipment & Materials Institute, Inc., 805 E. Middlefield Rd., Mountain View, CA 94043, 415/964-5111)

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
					1	2
3	4  INDEPENDENCE DAY	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24 31	25	26	27	28	29	30

**•10-15 AEA/Santa Clara Management Development Program**

Santa Clara (Mary Healy, AEA, 5201 Great America Parkway, Santa Clara, CA 95054, 408/987-4229)

**•11-13 National FinCom**

Jacob K. Javits Convention Center, New York (Jim Mion or Annie Zdinak, 333 Sylvan Avenue, Englewood Cliffs, NJ 07632, 800/237-7601, 201/569-6474)

**•11-15 2nd IEE/BCS Conference on Software Engineering 88**

University of Liverpool, England (IEE Conference Services, Savoy Place, London WC2R OBL, 01-240-1871 ext. 222)

**•12-15 INTERMAG '88 - Fourth Joint MMM-Intermag Conference**

Hyatt Regency Vancouver and Hotel Vancouver, Vancouver, British Columbia (Diane Suiters, Courtesy Associates, 655-15th Street NW, Washington, DC 20005, 202/639-5088)

**•13-15 3rd International Conference on Power Electronics and Variable-Speed Drives**

London (IEE Conference Services, Savoy Place, London WC2R OBL, 01-240-1871 ext. 222)

**•17-22 AEA Manufacturing Strategy Program**

Santa Cruz, CA (Stepahany Nickel, AEA, 5201 Great America Parkway, Santa Clara, CA 95054, 408/987-4239)

**•18-19 Engineers Expo Career Open House**

Melbourne/Orlando, FL (Engineers Expo, 2367 Auburn Avenue, Cincinnati, OH 45219, 513/721-3030)

**•19-21 2nd Workshop on Software Testing & Verification**

Rimrock Inn, Banff, Alberta, Canada (Lee White, Dept of CS, University of Alberta, Edmonton, Alberta, Canada, T6G 2H1, 403/432-4589)

**•24-29 1988 Power Engineering Society Summer Meeting**

Hilton and Marriott Hotels, Portland, OR (S. A. Annestrand, Bonneville Power Adm., Box 3621, Portland, OR 97208, 503/230-4503)

**•25-27 Summer Computer Simulation Conference**

Seattle, Washington (SCS, P.O. Box 17900, San Diego, CA 92117, 619/277-3888)

**•25-28 Navy Micro/OA '88 Conference**

San Diego (NARDAC San Diego, NAS North Island, Building 1482, San Diego, CA 92135-5110)

**•31-August 12 AEA/Stanford Executive Institute for Management of High-Technology Companies**

Stanford, CA (Mary Horngren Frost, AEA, 5201 Great America Parkway, Santa Clara, CA 95054, 408/987-4285)

# Your next destination:



# The ACL Computer Age.

## The future belongs to computers and peripherals built with RCA Advanced CMOS Logic (ACL).

The pressure is on to make your systems smaller, faster, cheaper.

Some of your competitors are doing just that by incorporating ACL into their new designs. If you want to stay on the fast track, you can't afford not to consider ACL for your new designs.

### **The computer of the future.**

Imagine a computer with power dissipation so low you could eliminate all cooling systems. Or design a sealed system to prevent dust problems.

And get dramatically improved reliability, thanks to the far lower heat generated. As well as far smaller system size.

You'd also be able to use it in a far wider operating temperature range ( $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ). Even in high-noise environments.

### **FAST\* speed, CMOS benefits.**

Advanced CMOS Logic gives you high speed (less than 3ns propagation delay with our AC00 NAND gate) and 24 mA output drive current.

But unlike FAST, it gives you a whole new world of design opportunity for computers, peripherals, telecommunications and other speed-intensive applications.

ACL dissipates less than 1/8 Watt while switching, compared to 1/2 Watt for a FAST IC (octal transceiver operating at 5 MHz). And quiescent power savings are even more dramatic: ACL idles at a small fraction of the power of a FAST IC.

\*FAST is a trademark of Fairchild Semiconductor Corp.

In addition, ACL offers balanced propagation delay, superior input characteristics, improved output source current, low ground bounce and a wider operating supply voltage range.

### **Latch-up and ESD protection, too.**

Latch-up concern is virtually eliminated, because ACL uses a thin epitaxial layer which effectively shorts the parasitic PNP transistor responsible for SCR latch-up.

And a dual diode input/output circuit provides ESD protection in excess of 2KV.

### **A broad and growing product line.**

Our line already includes over 100 of the most popular types (SSI, MSI and LSI). More are coming soon. And many are available in High-Rel versions.

### **All this at FAST prices.**

Our ACL line is priced comparably to FAST. So you get better performance at no extra cost. Why wait, when your competition is very likely designing its first generation of ACL products right now?

Get into the passing lane, with RCA ACL from the CMOS leader: GE Solid State. Free test evaluation kits are available for qualified users. Kits must be requested on your company letterhead. Write: GE Solid State, Box 2900, Somerville, NJ 08876.

For more information, call toll-free 800-443-7364, extension 24. Or contact your local GE Solid State sales office or distributor.



*GE Solid State*

### **GE/RCA/Intersil Semiconductors**

These three leading brands are now one leading-edge company. Together, we have the resources—and the commitment—to help you conquer new worlds.

In Europe, call: Brussels, (02) 246-21-11; Paris, (1) 39-46-57-99; London, (276) 68-59-11; Milano, (2) 82-291; Munich, (089) 63813-0; Stockholm (08) 793-9500.

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

**1-5 15th Annual Conference & Exhibition on Computer Graphics & Interactive Techniques (Siggraph '88)**

Georgia World Congress Center, Atlanta (University of Waterloo, Department of Computer Science, Waterloo, Ontario, Canada, N2L 3G1, 519/888-4534)

**•2 Basic IC Technology**

San Jose (ICE, 15022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

**•2-4 2nd SAMPE Metals & Metals Processing Conference**

Souffer Hotel, Dayton, OH (Marge Smith, SAMPE, International Business Office, 843 West Glentana (Box 2459), Covina, CA 91722, 818/331-0616)

**•2-4 1988 IEEE International Symposium on Electromagnetic Compatibility**

Westin Hotel, Seattle (Donald Weber, Conference Chairman, 131 SW 156th Street, Seattle, Washington 98166, 206/244-0952)

**•3 Mid-Term '88**

San Jose (ICE, 15022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

**•3-5 1988 IEEE 4th Workshop on Spectrum Estimation & Modeling**

Spring Hill Conference Center, Minneapolis (Kevin Buckley, Chairman, Department of Electrical Engineering, University of Minnesota, Minneapolis, MN 55455, 612/625-7319)

**•8-12 1988 IEEE International Conference on Systems, Man and Cybernetics**

Beijing Shenyang, China (A. Terry Bahill, University of Arizona, Systems & Industrial Engineering, Tucson, AZ 85721, 602/621-6561)

**•9 Basic IC Technology**

Scottsdale, AZ (ICE, 15022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

**•10 Mid-Term '88**

Scottsdale, AZ (ICE, 15022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

**•15-16 Engineers Expo Career Open House**

Colorado Springs/Denver (Engineers Expo, 2367 Auburn Avenue, Cincinnati, OH 45219, 513/721-3030)

**•16 Basic IC Technology**

Boston (ICE, 15022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

**•17 Mid-Term '88**

Boston (ICE, 15022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

**•23 Basic IC Technology**

Newport Beach, CA (ICE, 15022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

**•24 Mid-Term '88**

Newport Beach, CA (ICE, 15022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

**•30-September 1 MIDCON '88**

Dallas Convention Center, Dallas (Alexes Razezich, Electronic Conventions Mgmt., 8110 Airport Blvd., Los Angeles, CA 90045, 800/421-6816)

**30-September 2 ICO Topical Meeting on Optical Computing**

Orsay, France (Prof. S. Lowenthal, Institut D'Optique B.P. 43, 91406 Orsay, Cedex, France)

**31-September 2 Factory 2000: Integrating Information and Material Flow**

Churchill College, Cambridge, England (The Conference Secretariat, Institution of Electronic and Radio Engineers, Savoy Hill House, Savoy Hill, London WC2R 0JD, England)

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
				1	2	3
4	5 LABOR DAY	6	7	8	9	10
11	12 ROSH HASHANAH	13	14	15	16	17
18	19	20	21 YOM KIPPUR	22	23	24
25	26	27	28	29	30	

**•7-8 Capitol Microcomputer User Forum**  
Washington Convention Center, Washington, DC (Jackie Voight, National Trade Association, 800/638-8510 or 703/683-8500)

**•7-15 1988 International Test Conference**  
Sheraton Washington, Washington, DC (Doris Thomas, ITC, PO Box 264, Mt. Freedom, NJ 07970, 201/267-7120)

**•8 OEM Peripheral ICC**  
Newton Marriott, Newton, MA (Susie Ring, 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

**•11-15 Electromagnetic Compatibility**  
University of York, England (The Conference Secretariat, Institution of Electronic and Radio Engineers, Savoy Hill House, Savoy Hill, London WC2R 0JD, England)

**•11-15 14th European Conference on Optical Communication (ECOC 88)**  
Brighton, England (IEE Conference Services, Savoy Place, London WC2R 0BL, England, 01-240 1871, ext. 222)

**•11-16 1988 International Symposium on Subscriber Loops and Services (ISSLS '88)**  
Sheraton Hotel, Boston (C. William Anderson, New England Telephone Co., 350 Cochituate Road, Room 206, Framingham, MA 01701, 617/879-9000)

**•12-13 Engineers Expo Open House**  
Long Island (Engineers Expo, 2367 Auburn Avenue, Cincinnati, OH 45219, 513/721-3030)

**•12-15 1988 Petroleum & Chemical Industry Conference PCIC '88**  
Dallas (Thomas Pearson, ARCO Oil & Gas Company, PO Box 2819, Dallas, TX 75221, 214/880-4782)

**•12-15 Fabricating Composites '88 Conference & Exposition**  
Adam's Mark Hotel, Philadelphia (Nancy LePage, Society of Manufacturing Engineers, One SME Drive, PO Box 930, Dearborn, MI 48121, 313/271-1500)

**•12-15 1988 Annual International Test Conference**  
Sheraton Washington, Washington, DC (ITC '88, Computer Society of the IEEE, 1730 Massachusetts Avenue NW, Washington, DC 20036-1903, 202/371-1013)

**•12-16 1988 2nd International Conference on Properties and Applications of Dielectric Materials**  
Tsinghua University, Beijing, P.R. of China (Assoc. Prof. Zhu Deheng, Tsinghua University, Beijing, P.R. of China, 282451-2166)

**•13-15 Metal Matrix Composites '88 Conference**  
Adam's Mark Hotel, Philadelphia (Nancy LePage, Society of Manufacturing Engineers, One SME Drive, PO Box 930, Dearborn, MI 48121, 313/271-1500)

**•13-15 Semicon East**  
Bayside Expo, Boston (Bill Galarnea, Semiconductor Equipment & Materials Institute, Inc., 805 E. Middlefield Rd., Mountain View, CA 94043, 415/964-5111)

**•13-15 Failure Avoidance/Failure Analysis for VLSI Circuits**  
Boston (DM Data Inc., 6900 E. Camelback Rd., Suite 1000, Scottsdale, AZ 85251, 602/945-9620)

**•15 OEM Peripheral ICC**  
Frankfurt Sheraton, Frankfurt (Susie Ring, 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

**•15-16 38th Annual Broadcast Symposium**  
Washington Hotel, Washington, DC (Mr. Otto R. Claus, WBAL-TV, 3800 Hooper Avenue, Baltimore, MD 21211, 301/338-6455)

**•16 How to Save Thousands of Dollars on Your Semiconductor Purchases and System Designs**  
Boston (DM Data Inc., 6900 E. Camelback Rd., Suite 1000, Scottsdale, AZ 85251, 602/945-9620)

**•18-21 IEEE Artificial Neural Networks Conference**  
Sheraton International Conference Center, Reston, VA (Dr. Kamal Karma, 823 Fiegler Road, Gaithersburg, MD 20879, 301/984-7657)

**•19-22 Digital Processing of Signals in Communications**  
University of Loughborough, UK (The Conference Secretariat, Institution of Electronic and Radio Engineers, Savoy Hill House, Savoy Hill, London WC2R 0JD, England)

**•20 OEM Peripheral ICC**  
Stockholm Sheraton, Stockholm (Susie Ring, 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

**•20-22 NetWorld**  
Infomart, Dallas (Jim Mion or Annie Zdinak, 333 Sylvan Avenue, Englewood Cliffs, NJ 07632, 800/526-3247 or 201/569-6406)

**•20-22 PCB Expo 1988**  
Radisson Hotel South, Minneapolis (Heidi Hogarath, 1790 Hembree Rd., Alpharetta, GA 30201, 404/475-1818)

**•22 IEEE Videoconferences: Photonic Switching**  
IEEE Continuing Education Dept., 445 Hoes Lane, Piscataway, NJ 08854-4150, 201/981-0060 ext. 412)

**•23-27 International Broadcasting Convention**  
Brighton, England (IBC Secretariat, C/O Conference Services, IEE, Savoy Place, London WC2R 0BL, England, 01-240 1871, ext. 222)

**•26-27 North American Power Symposium**  
Purdue University, West Lafayette, Indiana (G. T. Heydt, Purdue University, Dept. of Electrical Engineering, West Lafayette, Indiana 47907, 317/494-3520)

**•26-28 1988 34th IEEE Holm Conference on Electrical Contacts**  
San Francisco Hilton & Tower, San Francisco (Registrar, IEEE Headquarters, 345 East 47th Street, New York, NY 10017-2394)

**•27 OEM Peripheral ICC**  
Hilton International, London (Susie Ring, 3151 Airway Avenue, #C-2, Costa Mesa, CA 92626, 714/957-0171)

**•27-29 FABTECH West Conference & Exposition**  
Anaheim Convention Center, Anaheim (Nancy LePage, Society of Manufacturing Engineers, One SME Drive, PO Box 930, Dearborn, MI 48121, 313/271-1500)

**•27-29 Finishing West Conference**  
Anaheim Convention Center, Anaheim (Nancy LePage, Society of Manufacturing Engineers, One SME Drive, PO Box 930, Dearborn, MI 48121, 313/271-1500)

**•27-29 20th SAMPE International Technical Conference**  
Hyatt Regency Hotel, Minneapolis (Marge Smith, SAMPE, International Business Office, 843 West Glentana (Box 2459), Covina, CA 91722, 818/331-0616)

**•27-29 Buscon '88 East**  
Penta Hotel, New York (Anne Weber, 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701, 213/402-1618)

**•27-29 Power Electronics '88 East**  
Penta Hotel, New York (Anne Weber, 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701, 213/402-1618)

**•27-30 AEA Executive Forum for Senior HR Professionals**  
San Diego (Diane McIntyre, AEA, 5201 Great America Parkway, Santa Clara, CA 95054, 408/987-4227)

**•28-29 California Electronics Show**  
The Pasadena Center, Pasadena, CA (Harry Schwartz, Epic Enterprises, Inc, 3838 Camino Del Rio North, Suite 164, San Diego, CA 92108, 619/284-9268)

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
						1
2	3	4	5	6	7	8
9	10 COLUMBUS DAY	11	12	13	14	15
16	17	18	19	20	21	22
23 30	24 31 HALLOWEEN	25	26	27	28	29

**-2-5 Mexican IEEE Annual Convention & Expo**

Plaza Hotel, Acapulco (William Warnes, LATCOM, PO Box 4749, Arlington, VA 22204, 703/685-0600)

**-2-6 Industry Applications Society Annual Meeting**

Pittsburgh Hilton, Pittsburgh (Charles E. Gray, General Electric Co., Two Gateway Center, Pittsburgh, PA 15222, 412/566-4173)

**-2-6 1988 International Conference on Computer Design**

Rye Town Hilton, Rye Brook, NY (ICCD 1988, 1730 Massachusetts Avenue NW, Washington, DC 20036-1903, 202/371-1013)

**-2-6 Joint Power Generation Conference**

Wyndham Franklin Plaza Hotel, Philadelphia (M.W. Migliaro, Ebasco Services, Inc., 2 World Trade Center, New York, NY 10048-0752, 212/839-2245)

**-3-4 Engineers Expo Career Open House**

Houston/Johnson Space Center (Engineers Expo, 2367 Auburn Avenue, Cincinnati, OH 45219, 513/721-3030)

**-3-5 1988 IEEE Ultrasonics Symposium**

McCormick Center Hotel, Chicago (William D. O'Brien, Jr., General Chairman, Bioacoustics Research Lab, University of Illinois, Urbana, IL 61801)

**-4 Semiconductor Packaging**

Boston (ICE, 105022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

**-4-6 AUTOTESTCON '88**

Hyatt Regency/Holiday Inn Downtown, Minneapolis (Lee C. Paulson, Honeywell, Inc., MN15-2733, 1625 Zarthan Avenue S., Minneapolis, MN 55416, 612/542-4841)

**-4-6 1988 International Display Research Conference**

Hyatt Islandia, San Diego (Ms. Hildegarde Hammond, Palisades Institute for Research Services, Inc., 201 Varick St., Room 1140, New York, NY 10014, 212/620-3388)

**-4-6 Adhesives, Surface Coatings & Encapsulants 1988 (ASE)**

Metropole Exhibition Centre, Brighton, England (Network Events, Ltd., Printers Mews, Market Hill, Buckingham, MK18 1JX, UK, 0280 815226)

**-4-6 Electronic Imaging Conference East**

World Trade Center, Boston (MG Expositions Group, 1050 Commonwealth Avenue, Boston, MA 02215, 617/232-EXPO)

**-4-6 National CASECON**

Jacob K. Javits Convention Center, New York (Jim Mion or Annie Zdinak, 333 Sylvan Avenue, Englewood Cliffs, NJ 07632, 800/922-0324, or 201/569-8542)

**-5-7 Practical IC Fabrication**

Boston (ICE, 105022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

**-9-13 International Conference on Computer Languages**

Castle Premier, Miami Beach (Pei Hsia, University of Texas/Arlington, Computer Science, 2100 Oak Bluff Drive, Arlington, TX 76001, 817/273-3785)

**-10-12 PC Expo**

McCormick Place North, Chicago (Jim Mion or Annie Zdinak, 333 Sylvan Avenue, Englewood Cliffs, NJ 07632, 800/922-0324 or 201/569-8542)

**-11-13 Adhesives '88 Conference & Exposition**

Hyatt Regency O'Hare, Chicago (Nancy LePage, Society of Manufacturing Engineers, One SME Drive, PO Box 930, Dearborn, MI 48121, 313/271-1500)

**-13-15 Northeast Computer Faire**

World Trade Center, Boston (Peter B. Young, The Interface Group, Inc., 300 First Avenue, Needham, MA 02194, 617/449-6600)

**-17-18 Engineers Expo Career Open House**

Dayton/Cincinnati (Engineers Expo, 2367 Auburn Avenue, Cincinnati, OH 45219, 513/721-3030)

**-17-19 ESC '88**

Orlando, FL (Joseph Gauthier, 919B Willowbrook Dr., Huntsville, AL 35802, 205/881-0947)

**-17-19 CONVERGENCE '88 International Congress on Transportation Electronics**

Hyatt Regency Hotel, Fairlane Towne Center, Dearborn, MI (Oliver T. McCarter, Advanced Engineering Staff, APE-S1-Council, 30200 Mound Road, Warren, MI 48090-9010, 313/986-8048)

**-17-19 4th International Conference on Satellite Systems for Mobile**

Communications & Navigation  
London (IEE Conference Services, Savoy Place, London WC2R OBL, England, 01-240 1871, ext. 222)

**-17-21 4th Expert Systems in Government Conference**

Washington, DC (ESIG '88, Computer Society of the IEEE, 1730 Massachusetts Avenue NW, Washington, DC 20036-1903, 202/371-1013)

**-18-20 Boston Manufacturing Productivity Conference & Advanced Productivity**

Exposition (APEX)  
Hynes Convention Center, Boston (Nancy LePage, Society of Manufacturing Engineers, One SME Drive, PO Box 930, Dearborn, MI 48121, 313/271-1500)

**-18-20 TESTMEX 1988**

Business Design Centre, London (Network Events, Ltd., Printers Mews, Market Hill, Buckingham MK18 1JX, UK, 0280 815226)

**-18-20 Failure Avoidance/Failure Analysis for VLSI Circuits**

Washington, DC (DM Data, Inc., Ste 1000, Scottsdale, AZ, 85251, 602/945-9620)

**-18-22 Ceramtec '88**

Munich Trade Fair Centre, Munich (Gerald Kallman, Kallman Associates, Five Maple Court, Ridgewood, NJ 07450-4431, 201/652-7070)

**-19-20 Semicon South West**

Infomart, Dallas (Bill Galamea, Semiconductor Equipment & Materials Institute, Inc., 805 E. Middlefield Rd., Mountain View, CA, 415/964-5111)

**-19-21 Canadian Communications and Energy Conference**

Queen Elizabeth Hotel, Montreal, Canada (IEEE Canadian Region Office, 7061 Yonge Street, Thornhill, Ontario, L3T 2A6 Canada, 416/881-1930)

**-20 IEEE Videoconferences: Photonic Switching**

IEEE Continuing Education Dept., 445 Hoes Lane, Piscataway, NJ 08854-4150, 201/981-0060 ext. 412)

**-21 How to Save Thousands of Dollars on Your Semiconductor Purchases and**

System Designs  
Washington, DC (DM Data Inc., 6900 E. Camelback Rd., Suite 1000, Scottsdale, AZ 85251, 602/945-9620)

**-21-23 RAINBOWfest**

Hyatt Regency Princeton, Princeton, NJ (Ira D. Barsky, The Falsoft Building, 9509 U.S. Highway 42, PO Box 385, Prospect, KY 40059, 502/228-4492)

**-23-26 1988 Military Communications Conference - MILCOM '88**

Irvine Marriott, Irvine, CA (Robert North, TRW Electronic Systems Group, One Space Park, Redondo Beach, CA 90278, 213/536-2421)

**-23-28 IPC Fall Meeting**

Anaheim Marriott, Anaheim (Virginia Perry, IIEPC, 7380 N. Lincoln, Lincoln Wood, IL 60646)

**-24-27 1988 Conference on Software Maintenance**

Paradise Valley Resort, Scottsdale, AZ (Computer Society of the IEEE, 1730 Massachusetts Avenue NW, Washington, DC 20036-1903, 202/371-1013)

**-24-28 AEA/Santa Clara Management Development Program**

Santa Clara, CA (Mary Healy, AEA, 5201 Great America Parkway, Santa Clara, CA 95054, 408/987-4229)

**-25-28 SYSTEC '88**

Munich Trade Fair Centre, Munich (Gerald Kallman, Kallman Associates, Five Maple Court, Ridgewood, NJ 07450-4431, 201/652-7070)

**-29-November 2 1988 International Telecommunications Conference (INTELEC '88)**

Town & Country Hotel, San Diego (Chris Riddleberger, AT&T, Room 1a-306, 260 Cherry Hill Road, Parsippany, NJ 07054, 201/299-3428)

**-31-November 2 AUTOFAC '88 Conference & Exposition**

McCormick Place, Chicago (Nancy LePage, Society of Manufacturing Engineers, One SME Drive, PO Box 930, Dearborn, MI 48121, 313/271-1500)

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
		1	2	3	4	5
6	7	8 ELECTION DAY	9	10	11 VETERANS DAY	12
13	14	15	16	17	18	19
20	21	22	23	24 THANKSGIVING DAY	25	26
27	28	29	30			

**•1-3 Toledo Manufacturing Productivity Conference & Advanced Productivity Exposition**

SeaGate Centre, Toledo, OH (Nancy LePage, Society of Manufacturing Engineers, One SME Drive, PO Box 930, Dearborn, MI 48121, 313/271-1500)

**•2-3 Failure Analysis Avoidance**

Scottsdale, AZ (ICE 105022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)

**•2-4 1988 IEEE Nuclear Science Symposium**

Sheraton Twin Towers (Edward J. Barsotti, Fermilab, PO Box 500, Batavia, IL 60510, 312/840-4061)

**•2-6 Communications 88/ Turkey**

Istanbul Hilton Convention & Exhibition Centre, Turkey (Gerald Kallman, Kallman Associates, Five Maple Court, Ridgewood, NJ 07450-4431, 201/652-7070)

**•7-8 International Conference on Refurbishment of Power Station Electrical Plant**

London (IEE Conference Services, Savoy Place, London WC2R OBL, England, 01-240 1871, ext. 222)

**•8-10 Semicon Korea**

Korea Exhibition Center, Seoul, Korea (Bill Galarnea, Semiconductor Equipment & Materials Institute, Inc., 805 E. Middlefield Rd., Mountain View, CA, 415/964-5111)

**•8-12 Electronica**

Munich Trade Fair Centre, Munich (Gerald Kallman, Kallman Associates, Five Maple Court, Ridgewood, NJ 07450-4431, 201/652-7070)

**•10-11 2nd International Symposium on Interoperable Information Systems**

Science Museum of Japan Science Foundation, Tokyo (Prof. Hideo Aiso, Dept. of EE, Keio University, 3-14-1, Hiyosi, Kohoku, Yokohama, Karagawa, 223 Japan, 044-63-1141 ext. 3320)

**•12-18 ACM/IEEE Computer Society FJCC**

Buena Vista Palace, Orlando, FL (FJCC Computer Society of the IEEE, 1730 Massachusetts Avenue NW, Washington, DC 20036-1903, 202/371-1013)

**•13-17 Saudi Elenex '88**

Riyadh Exhibition Centre, Riyadh, Saudi Arabia (Gerald Kallman, Kallman Associates, Five Maple Court, Ridgewood, NJ 07450-4431, 201/652-7070)

**•14-16 ATE '88 (Paris) Automatic Testing and Test Instrumentation**

Palais des Congres, Paris (Network Events, Ltd., Printers Mews, Market Hill, Buckingham MK18 1JX, UK, 0280 815226)

**•14-18 Supercomputing '88**

Hyatt Orlando, Kissimmee, FL (George Michael, Lawrence Livermore Labs., PO Box 808, L-306, Livermore, CA 94550, 415/422-4239)

**•15-17 Wescon/88**

Anaheim Convention Center, Anaheim (Alexis Razezovich, Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045, 213/772-2965)

**•15-17 Electronic Displays (ED88)**

Kensington Exhibition Centre, London (Network Events, Ltd., Printers Mews, Market Hill, Buckingham MK18 1JX, UK, 0280 815226)

**•15-17 Image Processing**

Kensington Exhibition Centre, London (Network Events, Ltd., Printers Mews, Market Hill, Buckingham MK18 1JX, UK, 0280 815226)

**•15-17 Interactive 1988**

Kensington Exhibition Centre, London (Network Events, Ltd., Printers Mews, Market Hill, Buckingham MK18 1JX, UK, 0280 815226)

**•18-21 Argentina ComExpo International Computer/Communications Expo**

Buenos Aires, Argentina (William Barnes, LATCOM, PO Box 4749, Arlington, VA 22204, 703/685-0600)

**•22-24 4th International Conference on Electrical Safety in Hazardous Areas**

Savoy Place, London (IEE Conference Services, Savoy Place, London WC2R OBL, England, 01-240 1871, ext. 222)

**•23-25 Semicon Japan**

Tokyo International Trade Center, Tokyo (Bill Galarnea, Semiconductor Equipment & Materials Institute, Inc., 805 E. Middlefield Rd., Mountain View, CA, 415/964-5111)

**•23-27 Elenex Turkey 88**

Istanbul Hilton Convention And Exhibition Centre, Istanbul (Gerald Kallman, Kallman Associates, Five Maple Court, Ridgewood, NJ 07450-4431, 201/652-7070)

**•28-30 International Conference on Overhead Line Design and Construction:**

**Theory and Practice (up to 150 kv)**

Savoy Place, London (IEE Conference Services, Savoy Place, London WC2R OBL, England, 01-240 1871, ext. 222)

**•28-December 1 Global Telecommunications Conference - GLOBECOM '88**

Diplomat Hotel, Ft. Lauderdale, FL (Richard Blake, Siemens Communications Systems, Inc., 5500 Broken Sound Blvd., Boca Raton, FL 33431, 305/994-7706)

# DECEMBER 1988

**EDN**

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
				1	2	3
4  CHANU- KAH	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25  CHRIST- MAS DAY	26	27	28	29	30	31

- 12-14 1988 Winter Simulation Conference  
San Diego, CA (John C. Comfort, Dept. of Mathematical Sciences, Florida International University, Miami, FL 33199, 305/554-2015)
- 5-8 Annual Infomatics '88 Conference  
Hong Kong (Don Avedon, International Information, Management Congress, PO Box 34404, Bethesda, MD 20817, 301/983-0604)
- 6-8 Composites in Manufacturing '88 Conference & Exposition  
Convention Center, Long Beach, CA (Nancy LePage, Society of Manufacturing Engineers, One SME Drive, PO Box 930, Dearborn, MI 48121, 313/271-1500)
- 6-9 1988 IEEE International Conference on Decision and Control  
Hyatt Regency Austin, Austin, TX (Michael P. Polis, National Science Foundation, 1800 G Street, Washington, DC 20550, 202/357-9618)
- 7 IEEE Videoconferences: Supercomputers  
(IEEE Continuing Education Dept., 445 Hoes Lane, Piscataway, NJ 08854-4150, 201/981-0060 ext. 412)
- 7-9 Practical IC Fabrication  
Orlando, FL (ICE 105022 N. 75th Street, Scottsdale, AZ 85260, 602/998-9780)
- 11-14 1988 IEEE International Electron Devices Meeting  
San Francisco Hilton, San Francisco (Melissa Widekehr, c/o Courtesy Associates, Inc., 655 15th Street NW, Suite 3000, Washington, DC 20005, 202/347-5900)
- 12-18 International Conference on Computer Vision  
Tarpon Springs, FL (Ruzena Bajcsy, Computer & Info. Science Dept., University of Pennsylvania, 200 S. 33rd Street, Philadelphia, PA 19104-6389, 215/898-6222)

Draft the best defensive players into your design. Contact Airpax Corporation, Cambridge Division, Woods Road, Cambridge, MD 21613. (301) 228-4600. Telex: 6849138, Fax: (301) 228-8910. A North American Philips Company.

# OUR GROWTH IS A MEASURE OF OUR DEDICATION TO OUR CUSTOMERS

A company can only grow with the confidence and support of its customers—and that must be earned by dedicated service. At Silicon Systems, we are proud of our growth record over the past few years. To achieve that growth we have studied our customers' specific application requirements and have developed families of products to meet those requirements.

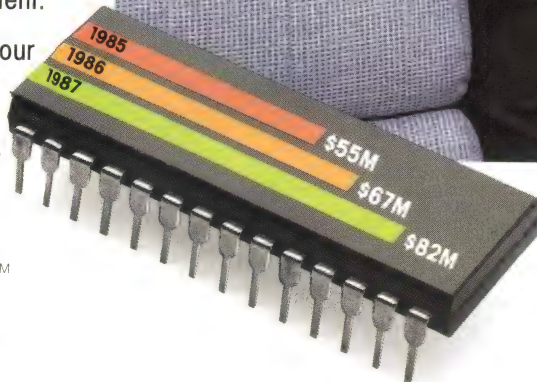
Although in the volatile semiconductor industry profitability does not always keep pace with revenue growth, in the long run the successful companies are those that concentrate their resources on serving their customers and their markets. And in the end, the rewards follow good business management and policies. That's why the management of Silicon Systems is equally dedicated to three constituents: its shareholders, its customers, and its employees.

Our fiscal year 1987 was marked not only by a substantial gain in revenues and profits, but also an overall strengthening of our balance sheet and a broadening of both our customer and product portfolios. We successfully completed a major reorganization and launched the company toward even more vigorous growth objectives for the future.

Starting the new year with orders up by more than 20% and a backlog 25% higher than the year previous, we look forward to fiscal 1988 as a year challenging us to post record high revenues with proportionate profitability. But we can only hope to achieve that goal by providing our customers with continued offerings of innovative products and dedicated service. That is our commitment.

For information on our company, our products, or our capabilities, contact:  
**Silicon Systems** 14351 Myford Road,  
Tustin, CA 92680, Phone: (714) 731-7110.

***silicon systems***™  
INNOVATORS IN INTEGRATION

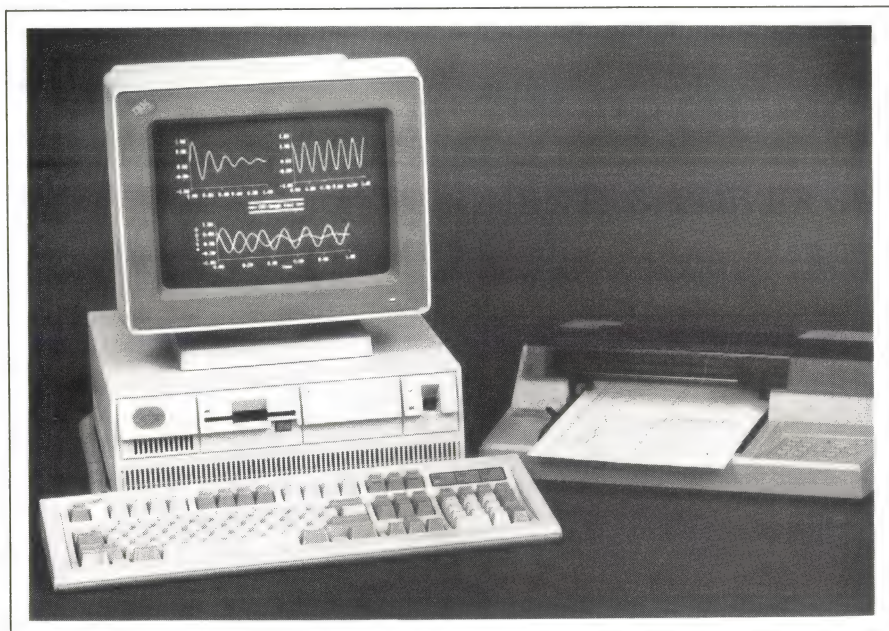


CARMELO J. SANTORO  
Chairman, President, and CEO

*"Where we design to your applications."*

# NEW PRODUCTS

## CAE & SOFTWARE DEVELOPMENT TOOLS



### PLOTTING SOFTWARE

- *Produces high-resolution graphs on PS/2 microcomputers*
- *Converts graphics data to a format usable by the PS/2*

Using the facilities of the machine's VGA (video graphics array) display board, CEC-Graph creates engineering graphics displays on the IBM PS/2 computer. The program is also compatible with the older CGA (color graphics adapter) and EGA (enhanced graphic adapter) display boards. Application programs written in Basic, Pascal, C, or Fortran can make use of the

package's ability to format, label, display, and plot graphics data. General-purpose commands permit the conversion of numeric or string data, acquired from GPIB- or RS-232C-based instruments, into the IEEE real-number format that is compatible with PS/2 programming languages. One command provides either a VGA display or directs the output to a plotter; the program automatically scales and labels graphs. \$95.

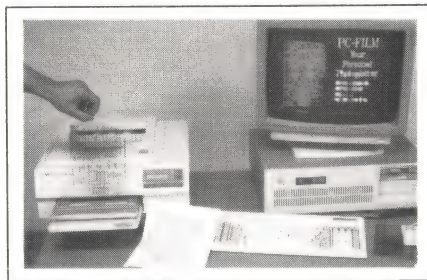
**Capital Equipment Corp.**, 99 S Bedford St, Suite 107, Burlington, MA 01803. Phone (617) 273-1818.

**Circle No 386**

### PHOTO-PLOT SYSTEM

- *Makes rasterized image from Gerber file*
- *Creates prototype artwork on laser printer*

The PC-Film photo-plotting package provides a rasterizer card that plugs into your IBM PC or compatible and software that interfaces the system to a 300-dot/in. laser printer. The system accepts a Gerber-type data file with as many as 255



apertures; converts such a file to a rasterized image; and transmits the rasterized image to a laser printer. The rasterizer card features 1.5M

bytes of onboard memory, which is sufficient to permit the creation of an 8x10½-in. image. You can use the system to create a paper plot to verify the accuracy of the Gerber file, and then create actual-size, pc-board artwork on film. A built-in feature that adjusts for film stretching and printer inaccuracies yields 4-mil accuracy at any point on a full page. The system will work with all word processors, and the vendor can supply direct-graphics drivers for AutoCAD, Ventura, and Publisher's Paintbrush software.

**CAD Solutions Inc.**, 2880 Zanker Rd, Suite 103, San Jose, CA 95134. Phone (408) 943-1610.

**Circle No 387**

### MENU BUILDER

- *Lets you build custom menus for running applications*
- *Provides password facilities and lets you select screen colors*

The Menu Works menu-building utility runs on IBM PCs, PS/2s, and compatibles equipped with hard disks. It facilitates operation of the PC for nontechnical users. You can set up a main menu that contains categories of programs, and sub-menus from which you can activate individual application programs. A password function lets you prevent unauthorized persons from running particular programs, viewing private menus, or changing the system configuration. The program lets you select any set of screen colors and automatically turns off the display if a user-defined period elapses without the occurrence of keystrokes. The utility eliminates the need to set up complex batch files; a single-keystroke selection from a menu lets you run as many as 15 separate programs and DOS commands. Special function keys display directories; give you immediate access to

on-line, context-sensitive help facilities; and let you set the time and date. \$59.95.

**PC Dynamics Inc.**, 31332 Via Colinas, Suite 102, Westlake Village, CA 91362. Phone (818) 889-1741.

**Circle No 388**

## 8085 SIMULATOR

- Lets you debug 8085 software on your PC or compatible
- Provides on-line help

The VM85 training program runs on IBM PCs and compatibles and simulates the operation of an Intel 8085  $\mu$ P. You can write 8085 source code with any text editor and assemble the code with the CASM85 assembler program, which is included in the package. The simulator then loads the assembler-produced listing file and executes it. With the aid of the package's graphics displays, you can examine or alter memory locations, registers, and flags. You can single step through your program or you can set breakpoints and run the program at full speed until it reaches one of them. The simulator also lets you read from and write to I/O ports, and generate interrupts from the keyboard. To run the simulator, you'll need an IBM PC or compatible with at least one floppy-disk drive, 64k bytes of free memory, and DOS version 2.1 or higher. \$29.95.

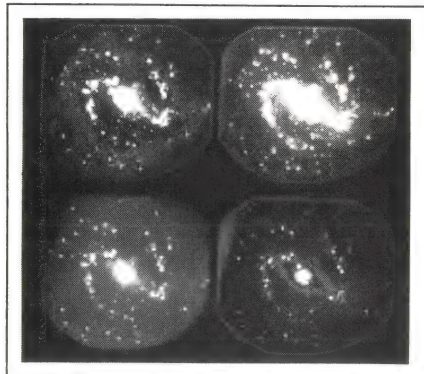
**J-Tron Systems**, Box 1232, Piscataway, NJ 08854.

**Circle No 389**

## IMAGE SOFTWARE

- Lets you acquire images from video equipment and scanners
- Provides 250 image-manipulation and -analysis functions

The interactive DT/IDL image-processing software runs on a MicroVAX II workstation and provides easy access to 250 frame-grabbing, image-analysis, filtering, and plotting functions. The software performs typed or mouse-selected commands



immediately, but you can also group command sequences in files that automatically execute complex sequences. The interactive data language has English-like commands and syntax, and lets you use the package whether or not you are conversant in advanced mathematics or programming. The package's image-processing functions include frame-grabbing, convolution, FFT analysis, histogram creation, median filtering, zooming, plotting, and wrapping, rotating, or translating. You can create entirely new commands by combining the built-in commands, or you can write new function routines in any language supported by the VAX Calling Standard. To use the software, you need a MicroVAX II workstation equipped with an analog RGB monitor and the vendor's DT2651 High-Resolution Frame Grabber. \$3750.

**Data Translation Inc.**, 100 Locke Dr., Marlboro, MA 01752. Phone (617) 481-3700. TLX 951646.

**Circle No 390**

## ON-LINE MANUALS

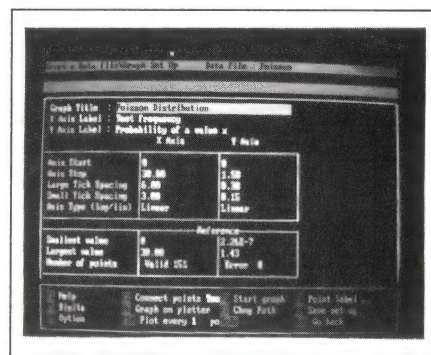
- Have hot keys that provide context-sensitive language help
- Available with reference databases for four languages

The Norton On-Line Programmer's Guides provide reference material for 8088 assembly language as well as for the Basic, Pascal, and C languages. You load a RAM-resident access program (which occupies 65k bytes) and a language database; while you're running an application

program, pressing Shift and F1 puts the language-database menu on the screen. You can call up the detailed reference entry or short definitions; or you can search for a key word or look for related cross-references. For the resident mode, you load the access program and guide before running any other program, and they remain available until you uninstall them. For the pass-through mode, you load the guide on the same command line as your application; when your application terminates, the access program is automatically uninstalled, freeing the memory for other programs to use. Access program and one language database, \$100; additional language databases, \$50 each.

**Peter Norton Computing Inc.**, 2210 Wilshire Blvd, Suite 186, Santa Monica, CA 90403. Phone (213) 453-2361. TWX 650-226-1869.

**Circle No 391**



## EQUATION PROCESSOR

- Evaluates keyboard-entered mathematical equations
- Automatically creates a data file for later use

Equator lets you enter equations from the keyboard of your IBM PC or compatible, evaluates them, and sends the results to a data file as well as to the screen or to a plotter. The program handles Greek and other special characters, extracts the value of common constants such as  $\pi$  or  $h$  (Planck's constant) from a table, and lets you assign values to variables. When producing a graph, the software automatically scales

the graph's axes to fit on the output medium that you select. In evaluating an equation, the program makes use of 36 operators and mathematical functions. You can also use previously evaluated equations as part of the current operation. The menu-driven command structure lets you define the equation and variables quickly and with minimal training. The program provides context-sensitive, on-line help. To run the program, your PC must have at least 512k bytes of RAM and run PC-DOS version 2.1 or higher. For plotting, you can use a Hewlett-Packard 7470 plotter or its equivalent, or a dot-matrix printer with graphics capability. \$79.

**Pulse Research**, Box 696, Shelburne, VT 05482. Phone (802) 985-2928.

**Circle No 392**

## MATH SOFTWARE

- *Runs on the Apple Macintosh*
- *Provides wide range of math functions with graphics features*

MathView Professional is a stand-alone, interactive, mathematical package. It lets you evaluate and tabulate several variables simultaneously. You can plot as many as 10 functions simultaneously in Cartesian or polar coordinates, plot parametric relationships and raw data sets, and plot surfaces in three dimensions, with the option of removing hidden lines. Other functions include solving linear systems of equations or eigenvalues for symmetric matrices; computing direct and inverse FFTs; performing extensive matrix operations; solving nonlinear systems of equations, using either Newton's method or the Broyden algorithm; solving ordinary and partial differential equations; and computing integrals by various methods. In addition to providing a comprehensive set of descriptive statistical functions, the package lets you determine series coefficients and Chebyshev, Legendre, and Bessel elliptic functions. To

run the package, you need a Macintosh equipped with at least 512k bytes of RAM, 128k-byte (or larger) ROMs, and two 800k-byte floppy-disk drives or a hard disk. \$249.95.

**Brainpower Inc.**, 24009 Ventura Blvd, Suite 250, Calabasas, CA 91302. Phone (818) 884-6911.

**Circle No 393**

## LOGIC SIMULATOR

- *Handles bidirectional, charge-sharing, and wired logic*
- *Can model both strong and weak transistors*

The DSim event-driven, mixed-level simulator allows both switch- and gate-level simulation. Its features make it particularly suitable for



**Dotronix Engineers work closely with you to design products that meet your exacting requirements.**

Monochrome Displays from 3" to 25"  
Color Displays from 10" to 19"  
Fixed- and Multi-Frequency

### Applications include:

Desktop Publishing	Bank/Brokerage Terminals
CAD/CAM/CAE and Graphics	Airline Flight Information
Medical Imaging/Diagnostics	Government/Military
Industrial Process Control	
Test and Measurement Instruments	
Closed Circuit TV Security Systems	

Includes the full product line of Video Monitors, Incorporated, a subsidiary of Dotronix, Inc.

## DOTRONIX, INC.

160 First Street S.E. New Brighton, Minnesota 55112-7894

(612) 633-1742 TWX: 9105633541

FAX: (612) 633-7025

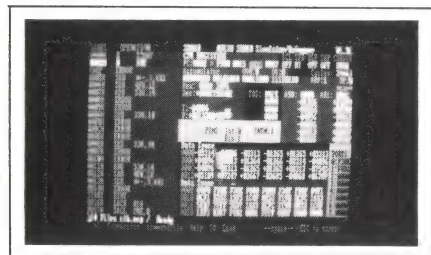
Facilities in Minnesota, Wisconsin and Taiwan

**CIRCLE NO 21**

MOS simulation, but you can use it to simulate other digital logic families, too. The enhanced switch models can represent both strong and weak transistors, and can handle bidirectional, charge-sharing, and wired logic. Timing-violation models allow the program to detect setup and to hold violations at both the switch and the gate levels. A macro language lets you describe, in detail, a complex block of logic and to use this description as many times as you wish by calling the macro. According to the vendor, the combination of delay modeling and enhanced switch simulation not only increases accuracy, but also permits spike analysis. The simulator can correctly simulate the four-transistor exclusive-OR gate at the switch level. License for IBM PC version, \$2500; for Apollo workstation version, \$20,000.

**Roche Systems Corp.**, 1705 N Rankin St, Appleton, WI 54911. Phone (414) 733-6077.

**Circle No 394**



## DSP SIMULATORS

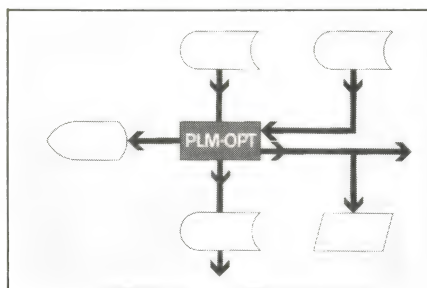
- Run on IBM PCs and compatibles
- Simulate TMS 32010 and TMS 32020 families of DSP chips

The AVSIM321 and AVSIM322 are software simulators/debuggers for the Texas Instruments 32010 and 32020 families of digital signal-processing chips. They run on an IBM PC or compatible and interactively execute object code under the control of a full-screen symbolic debugger. The screen display shows you the current instruction stream and the contents of registers, flags, and areas of data memory. You can ex-

amine and modify these at any time; by using an Undo key, you can back up, one instruction at a time, through recently executed instructions to determine where an error occurred. You can either issue commands from a menu structure or from a command line. \$379 each.

**Avocet Systems Inc.**, Box 490, Rockport, ME 04856. Phone (207) 236-9055.

**Circle No 395**



## COMPILER

- Provides support for 8051-family microcontrollers
- Is compatible with popular in-circuit emulators

The PLM-51 cross compiler, the A51 macro cross assembler, and a set of object format utilities run in an MS-DOS environment and cover all stages of software development for 8051, 8052, 8044, and SAB80515  $\mu$ controllers. All these software tools are compatible with popular in-circuit emulators, including Mice-II, Hitex, and Intel emulators. The cross compiler conforms to the Intel language definition. Because the cross compiler closely resembles PLM-80 and PLM-86, you can, with little modification, port software written for these compilers to 8051-family microcontrollers. Features of PLM-51 that suit it for use with the 8051 architecture include support for Boolean operations, control over placement of code and data items in the target system, and extensive code optimizations. The compiler produces output in either assembly-language or relocatable-object format. It comes with a run-time support library in relocatable format

and with register description files for the microcontrollers. The A51 assembler supports macroprocessing, public/external bit variables, and all the memory areas and special-function registers of the microcontrollers. It produces a relocatable output file that you can link to output files from the PLM-51 compiler. PLM-51 cross compiler, Sw Fr 1450; A51 assembler, Sw Fr 550; object format utilities, Sw Fr 650.

**Sysoft SA**, 6926 Montagnola, Switzerland. Phone 091 543195. TLX 79671.

**Circle No 396**

## FORTRAN FOR 80386

- Provides all features of Fortran-77 and 4.2 BSD extensions
- Produces code that is globally optimized for speed or size

The NDP Fortran-386 globally optimizing compiler makes full use of the features of the 80386  $\mu$ P. It generates 80386 native code that runs under MS-DOS or Unix System V. The compiler simplifies the porting of existing applications to 80386-based machines by implementing all the features of ANSI Standard X3.9-1978 for Fortran-77, as well as the documented and undocumented extensions of the Berkeley 4.2 BSD f77 Unix compiler. The only limit on the size of programs, procedures, and arrays is 4G bytes or the amount of memory in the system. The compiler generates in-line code for a numeric coprocessor; it can make use of the vendor's mW1167 instruction set or of the numeric transcendentals of the 80387 coprocessor. The compiler outputs assembly language, which you can assemble and link with either Unix System V tools or the PharLap (Cambridge, MA) tools for MS-DOS. \$595.

**MicroWay**, Box 79, Kingston, MA 02364. Phone (617) 746-7341. TLX 503014.

**Circle No 397**

# CHINON: Scanning the future.



Chinon's design engineers have a serious commitment to produce the most technologically advanced products that the mind of man can imagine.

That commitment has created subsystems, peripherals and components that could change the way we think about computers—and change the way computers are used.

The Scanner and the CD-ROM units pictured here are the types of products that continually move the leading edge forward. The Scanner could change the way business works by making true OCR technology more affordable and easier to use than ever before. The unique scanning head design means that the document to be scanned remains fixed, unlike other scanners that

can only accept a single sheet fed through the unit. It is also extremely compact and lightweight, and is designed to set new standards of cost-effectiveness.

CD-ROMS can provide users with access to databases that, only a few years ago, were possible only with a mainframe system.

Technology is still moving as fast as the best minds can advance it. At Chinon, our commitment to that progress keeps our products at the very forefront of the leading edge. We're bringing the future of computing to the needs of today.

## CHINON

Chinon America, Inc., 6374 Arizona Circle  
Los Angeles, CA 90045 (213) 216-7611 FAX: (213) 216-7646

# "EDN MAGAZINE HAS BEEN A CONSISTENT WINNER FOR THE SGS BRIGHTER POWER CAMPAIGN."

Daniel Queyssac  
President  
SGS Semiconductor Corporation

**As president of SGS Semiconductor Corporation,** Daniel Queyssac set a goal of establishing SGS as a leader in power MOS and an innovator in smart power devices. The Brighter Power campaign was created to help get the job done.

To insure that the right audience — design engineers — would get the message, SGS needed the right vehicle. For Queyssac, EDN was the logical choice. "It had performed very well for SGS in the past," says Queyssac, "so, naturally, we expected good results."

"EDN's pulling power exceeded our expectations. In fact, our Brighter Power ads drew inquiries in record numbers."

"EDN will remain at the top of the SGS media list simply because it works."



Advertising in EDN magazine works for  
SGS Corporation. It can work for you.

**EDN**

**Where Advertising Works**

# NEW PRODUCTS

## TEST & MEASUREMENT INSTRUMENTS

### 8085 EMULATOR

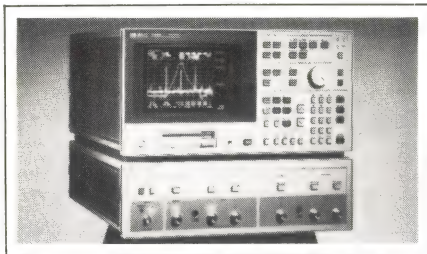
- 64k bytes of overlay RAM are mappable in 1-byte blocks
- Supports devices clocked at 10 MHz with no wait states

The 8085-64K Icebox in-circuit emulator emulates all versions of the 8085  $\mu$ P at speeds as high as 10 MHz, without adding wait states. It can work with processor chips that are soldered in place. You can access the target system by clipping a cable onto the processor chip; you don't have to unplug a socketed processor to connect the emulator. The emulator is compatible with the vendor's TraceAlyzer real-time trace and performance-analysis option. The unit includes 64k bytes of overlay RAM, mappable in increments as small as 1 byte, anywhere in the target system's address space. The device has 65,536 hardware breakpoints; you can set breakpoints on read, write, or fetch

cycles. You can also set breakpoints individually or in groups. \$1395.

**Softaid Inc.**, 8930 Rt 108, Columbia, MD 21045. Phone (800) 433-8812; in MD, (301) 964-8455.

Circle No 398



### 500-MHz ANALYZER

- Performs spectrum and vector network analysis
- Includes color graphics display

The HP 4195A combines the functions of a vector network analyzer and a spectrum analyzer in a single instrument that costs no more than a single-function instrument capa-

ble of operating in the same frequency band. The unit, which operates from 10 Hz to 500 MHz, includes a color CRT capable of presenting numeric data in tabular form or graphics displays in rectangular, polar, or Smith format. As a spectrum analyzer, its dynamic range is  $>70$  dB; as a network analyzer, it exhibits an amplitude accuracy of  $\pm 0.5$  dB and a phase accuracy of  $\pm 0.3^\circ$ . Built into the instrument is a 3½-in. floppy-disk drive; you can use it to store setups (control settings), measured data, tables of frequencies to include in sweeps, and programs that execute custom functions. You write these programs in a language that resembles Basic. \$23,000; high-stability reference-oscillator option, \$850. Delivery, six weeks ARO.

**Hewlett-Packard Co.**, 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local office.

Circle No 399

### BUS ANALYZER

- Diagnoses faults in MIL-STD-1553 systems
- Includes 20M-byte hard disk

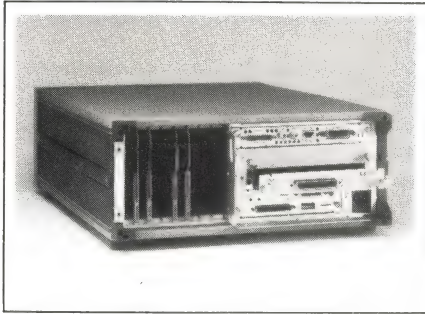
The ABA 500 is a portable or rack-mountable unit based on a 68000  $\mu$ P clocked at 8 MHz. It includes 1M bytes of RAM, a detachable keyboard, an electroluminescent display, and, optionally, a 20M-byte hard disk or a 5¼-in. floppy-disk drive. It can automatically test systems based on the MIL-STD-1553 bus, or units intended for connection to the bus, for compliance with the bus protocol. It can also act as a bus controller, as a remote terminal on the bus, or as a monitor of all bus traffic. When used as a monitor, it provides extensive diagnostic displays; for off-line analysis, it can store bus-traffic records as long as 2.3M bytes. RS-232C, IEEE-488, and Centronics-parallel interfaces



are standard, thus facilitating the unit's use in ATE systems. \$22,950 for rack-mount version; \$25,950 for portable version. Delivery, eight weeks ARO.

**Interface Technology**, 2100 E Alosta Ave, Glendora, CA 91740. Phone (818) 914-2741. TLX 494-5489.

Circle No 400



## CONTROLLER

- Single unit houses CPU and instrument cards
- 7-in. rack mounts

The HP 6954A multiprogrammer is a 7-in.-high rack-mountable unit containing a computer identical to the HP 9000 Model 310 and eight slots in which you can place instru-

mentation cards from the HP 69700 family. Because of the 6954A's construction, many small dedicated automatic test systems, which previously required separate units for the CPU and the instrument cards, now fit in a single unit. The computer, which is based on a 68010  $\mu$ P, includes 1M bytes of RAM and a 20M-byte hard disk. If you add an optional keyboard and video display, you can use the unit for program development as well as for instrument control. As soon as you apply power, you can access a special version of the Basic language, which incorporates extensions for instrument control. When you use the computer as a dedicated controller, you can communicate with it via an RS-232C port that's included as a standard feature. An IEEE-488 interface lets you control external instrumentation. In the 69700 series of card-level instruments, 30 models are available, including new timebase and counter cards. Multiprogrammer, \$10,400; keyboard and CRT, \$595; expansion chassis for 14 additional cards, \$3800; instrument cards, \$415 to \$2350.

**Hewlett-Packard Co.**, 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local office.

**Circle No 401**

# Turn Good Ideas Into Good Articles

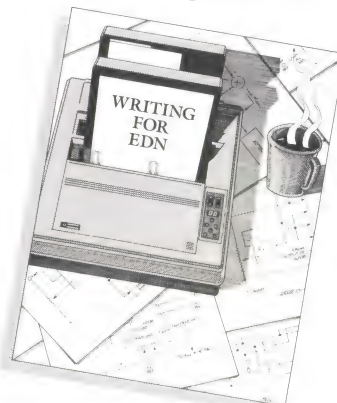
*With EDN's FREE Writer's Guide!*

Would you like to get paid for sharing your clever engineering ideas and methods with your professional colleagues? If so, then send for EDN's new FREE writer's guide and learn how.

You don't need the skills and experience of a professional writer. And you don't need to know publishing jargon. All you *do* need are a little perseverance, your engineering skills, and the ability to communicate your ideas clearly.

Our new writer's guide takes the mystery and intimidation out of writing for a publication. It shows you how to write for EDN using skills you already have. Plus, it takes you step-by-step through the editorial procedures necessary to turn your ideas into polished, professional articles.

*Get your FREE copy of EDN's writer's guide by circling number 800 on the Information Retrieval Service Card or by calling Sharon Gildea at (617) 964-3030.*



## 68020 PROBE

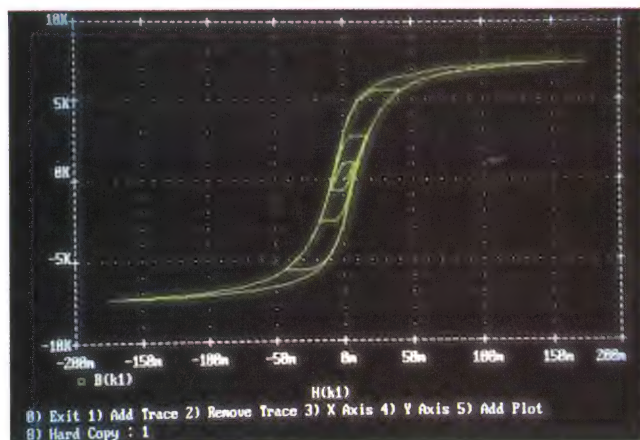
- Displays cache hits at 20 MHz
- Provides time-correlated trace in dual- $\mu$ P systems

The 68020 probe works with the vendor's SAW (software analysis workstation). It supports the 68020's onboard cache. You don't have to disable the cache to use the workstation. If you do not display cache hits, you can operate the  $\mu$ P with a 25-MHz clock; if you display cache-hit cycles, you can use a 20-MHz clock. The disassembler provides symbolic disassembly and transfer-of-control filtering. It works with the 68020's dynamic-bus-sizing feature. The workstation

# PSpice

## Simulation

### With Enhancements for Power Electronics



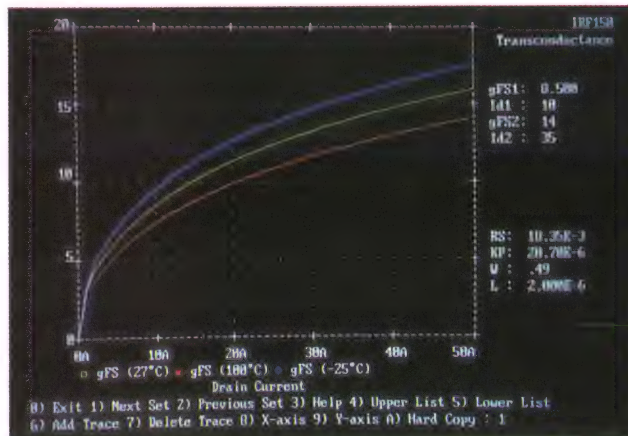
B-H curve from a core in the PSpice transformer library

Since its introduction four years ago, MicroSim's PSpice has sold more copies than all other SPICE-type simulators combined. Many of these customers work with power electronics. Why do so many power designers choose PSpice? Perhaps because every copy of PSpice includes these features:

- A non-linear magnetics model based on the Jiles-Atherton ferromagnetic equations. It models saturation, hysteresis, eddy current losses, and air gap effects. Instead of approximating the core by using separate equations for different operating regions and then "gluing" the results together, the PSpice model uses one set of equations which describes the core's entire behavior.
- A library of power MOSFET's. The MOSFET equations in PSpice have been enhanced to allow more convenient and accurate modeling of power devices.
- Ideal switches. Logarithmic interpolation for the ON/OFF transition avoids numerical problems.

Or perhaps because of these options available for PSpice:

- Monte Carlo analysis to calculate the effect of parameter tolerances on circuit performance.
- The Probe "software oscilloscope", allowing interactive viewing of simulation results. The left photograph above is a Probe display.



Characterizing a power MOSFET using Parts

- The Parts parameter extraction program, allowing you to extract a device's model parameters from data sheet information. The right photograph above shows a step in characterizing a power MOSFET.

Or perhaps because PSpice is available on these computers:

- The IBM PC family, including the PS/2 and the Compaq 386.
- The Sun 3 workstation.
- The VAX/VMS family, including the MicroVAX II.

Or perhaps it is our extensive product support. Our technical staff has over 50 years of experience in CAD/CAE and our software is supported by the engineers who write it. With PSpice, expert assistance is only a phone call away.

Please call or write today for a free evaluation version of PSpice. Find out for yourself why PSpice is the standard for analog circuit simulation.



**MicroSim Corporation**

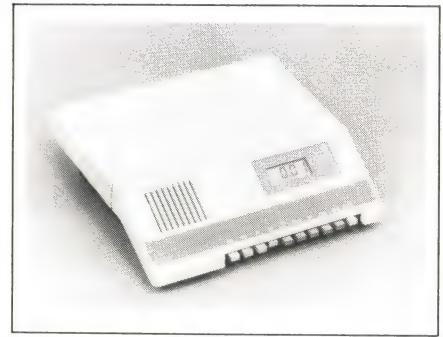
23175 La Cadena Drive • Laguna Hills, CA 92653  
(714) 770-3022 • (800) 826-8603 • Telex: 265154 SPICE UR

PSpice is a registered trademark of MicroSim Corporation

can monitor the operation of software in real time to determine how many times every routine executes. It also allows symbolic tracing for branch analysis as well as assembly-level tracing. In dual-processor systems—for example, where a 68020 acts as a backup processor for a 68020 main processor, a dual display in trace mode allows you to time

correlate the interaction between the processors. SAW system, configured for 68020 code development and excluding the host IBM PC/AT, \$24,690; 68020 probe only, \$2500; disassembler, \$765.

**Northwest Instrument Systems,**  
19545 NW Von Neumann Dr,  
Beaverton, OR 97075. Phone (503)  
690-1300. **Circle No 402**



## LOCATER

- *Locates accessible and inaccessible short circuits*
- *Includes voltage- and resistance-measurement ranges*

The 850 short-circuit locator employs three different techniques to help you track down short circuits in electronic assemblies without cutting pc-board traces or lifting component legs. First, the instrument's 2-m $\Omega$  ranges, with full ranges of 40 m $\Omega$  and 200 m $\Omega$ , allow you to locate shorts between pc-board traces or component legs by finding the point of minimum resistance. Second, for higher-resistance faults, a 2-mV range with  $\mu$ V resolution allows you to trace current flow along pc-board traces. Finally, a magnetic field-sensing current probe allows you to trace inaccessible current paths—for example, through ICs or through buried tracks in multilayer pc-boards. All these tracing techniques are accompanied by a variable-tone audible indication and a meter reading. A voltage source, variable between 0 and 550 mV, drives sections of the unit under test for the voltage-drop and current-tracing tests. The tester also has general-purpose 20-mV, 2V, and 20V voltage-measurement ranges, and resistance-measurement ranges of 2 $\Omega$ , 200 $\Omega$ , and 20 k $\Omega$ . £495.

**Polar Instruments Ltd,** Box 97,  
St Sampson's, Guernsey, UK.  
Phone (0481) 53081. TLX 4191591.

**Circle No 403**

## POMONA keeps your test instruments honest.

Your test instruments are periodically calibrated, but you can't rely on their accuracy unless you have confidence in your interconnecting accessories. So, considering the high cost of instruments versus the low cost of accessories, it just makes good sense to rely only on the very best quality test accessories to keep your test instruments honest: POMONA.



For your FREE 1988 General  
Catalog, circle reader service  
number printed below

**POMONA**  
**ITT Pomona Electronics**

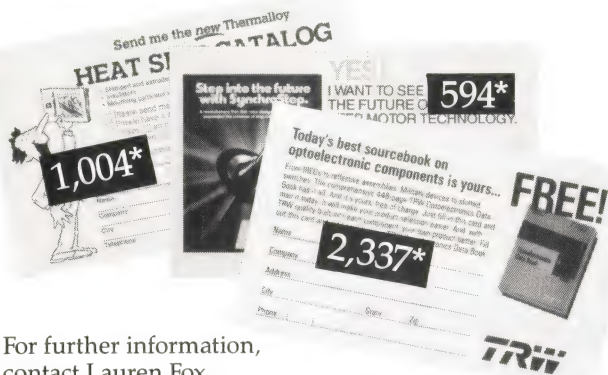
# SEE IF YOU KNOW A GOOD AD WHEN YOU SEE IT

*and  
win a camcorder!*

Details  
on Page  
51.

## EDN INFO CARDS

The Fastest,  
Most Cost-Effective Way  
to Generate Sales Leads!



For further information,  
contact Lauren Fox,  
EDN Info Cards Manager,  
at (203) 328-2580.

\* Numbers represent actual  
responses

Nine Test Probes  
with only one difference  
between them and your  
scope's original equipment

Manufacturers Scope	Original Probe	Price	Coline/TPI Equivalent	Price
TEKTRONIX				
2300 Series	P6101A	\$53	M12X1	\$38
	P6108A	\$75	M12X10	\$62
2200 Series	P6121	\$100	M12X10AP	\$68
	P6122	\$58	P100	\$38
2400 Series	P6131	\$140	M15X10HFAP	\$87
	P6133	\$115	M12X10AP	\$68
400 Series	P6105A	\$93	M12X10AP	\$68
	P6106A	\$140	M15X10HFAP	\$87
	P6130	\$130	M12X10AP	\$68
IWATSU				
SS-5321	SS-0014	\$92	M12X10	\$62
SS-5711	SS-0012	\$77	M12X10	\$62
LEADER				
LBO-315	LP-060X	\$60	SP100	\$43
LBO-518	LP-100X	\$76	SP100	\$43
PHILIPS				
PM3267	PM8924	\$60	M12X1	\$38
&				
PM3256	PM8926	\$70	P100	\$38
PM3264	PM8928	\$95	M12X10	\$62
HITACHI				
V-1100A	} AT-10AL1.5	\$64	SP100	\$43
V-670				
V-509				
HEWLETT PACKARD				
1715A	10018A	\$135	M20X10	\$68
1722B	10017A	\$130	M15X10HF	\$79
1725A	10017A	\$130	M15X10HF	\$79
1740 Series	10041A	\$135	P100	\$38
	10021A	\$85	IP20	\$29

Take up the TPI challenge and compare our prices with the probes you currently use. In many cases you can replace both probes on your dual trace scope at the cost of one probe from the scope manufacturer. Plus, bandwidth and overall performance of the TPI probe typically exceed that of the original equipment. Satisfaction is guaranteed with a ten day return privilege. TPI Specialists in probes for over 15 years.

Available from your local distributor.

TOLL FREE INFORMATION LINE

1-800-368-5719,

1-800-643-8382 in California

**TEST  
PROBES, INC.**



9178 Brown Deer Road,  
San Diego CA, 92121  
Phone: (619) 535 9292

CIRCLE NO 158

Send to: 9178 Brown Deer Road, San Diego CA, 92121  
☐ Name  
☐ Please send full line catalog  
 Company  
 Address  
 Phone: EDN010788

# We're Teaming With Software



## For Multilingual Data Acquisition

We can take your IBM® PC/AT/XT, and compatibles, and now the new **Personal System/2™ Model 30**, to new heights in power and productivity. Our popular and versatile PCI-20000 Personal Computer Data Acquisition System is teaming up with the leading software houses, and we can offer you the most efficient drivers for the most popular programming languages, in addition to applications packages that require *no* programming expertise.

### Look At The Languages

There are time-saving drivers for BASIC, Turbo Pascal™, Microsoft® C, ASYST™, and assembler. These include a complete set of tools for analog, digital, and counter/timer functions including high-speed DMA.

### Look At The Many Specific Applications Solutions

They include Labtech Notebook®, Real Time Access®, Relay Ladder Logic RD 1000/PC™, DADISP™, Snapshot™ Storage Scope, and PCI ControlLOGraph.

Also, there's compatibility with Lotus 1-2-3™, CODAS™, The Fix™, Genesis™, Labtech Chrom®,  $\mu$ DAD™, ONSPEC™, Paragon Control™, SNAP-FFT™, Unkscope™, and Waveform Scroller™.

### Look At The Applications

Applications include Automatic Test Systems, Burn-In, Process Control,

Industrial Monitoring, Data Logging, Incoming Inspection, Laboratory Automation, Pollution Archiving, Transient Recording, Structural Analysis, Temperature Monitoring, Product Evaluation, Life Testing, Engine Testing, Event Capture, and the list goes on.

Now you've got flexible and versatile software for the most flexible and versatile hardware on the market. Let PCI-20000's MODULAR MAGIC solve your data acquisition, test, measurement, and control problems.

Please contact us for complete information, Burr-Brown International Literature Distribution Center P.O. Box 7735, 1117 ZL Schiphol The Netherlands. **For even faster response, call 020 470 590.**



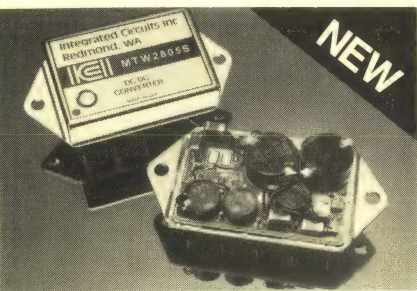
**High Performance  
PC Data Acquisition Systems**

IBM®, Personal System/2™ IBM Corp.; Turbo Pascal™ Borland International Inc.; Microsoft® Microsoft Corp.; ASYST™ Macmillan Software Co.; Labtech Notebook®, Real Time Access®, Labtech Chrom® Laboratory Technologies Corp.; RD 1000/PC™, Control Process Inc.; DADISP™ DSP Systems; Snapshot™, SNAP-FFT™ HEM Data Corp.; Lotus 1-2-3™ Lotus Development Corp.; CODAS™, Waveform Scroller™ Dataq Instruments, Inc.; The Fix™ Intellution, Inc.; Genesis™ Iconics Inc.;  $\mu$ DAD™ Industrial Control Specialists Inc.; ONSPEC™ Heuristics Inc.; Paragon Control™ Intec Controls Corp.; Unkscope™ Unkel Software Inc.

# EDN PRODUCT MART

This advertising is for new and current products.

Please circle Reader Service number  
for additional information from manufacturers.



**NEW**

## MTW2805S - MINIATURE DC-DC CONVERTER - 30 WATTS

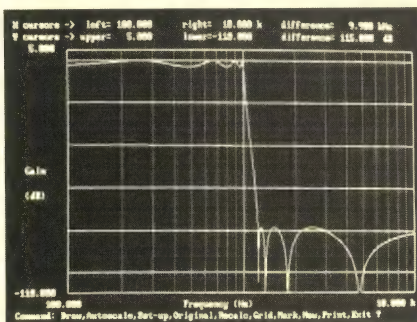
Integrated Circuits Inc. announces the MTW2805S, the latest complement to their line of high efficiency, thick film hybrid, DC-DC Converters.

Measuring only 1.95" x 1.35" x 0.50" the hermetically sealed MTW2805S generates a fully isolated +5VDC/6amp. output over the input rate of 19-40 VDC from -55°C to +85°C with 82% efficiency (typ.) Other features include short circuit protection, remote load voltage sensing, internal I/O ripple filters, an inhibit function and optional environmental screening \$420/100 stock. For additional information, contact:

### INTEGRATED CIRCUITS INCORPORATED

10301 Willows Road, Redmond, WA 98052  
Telephone (206) 882-3100  
FAX (206) 882-1990 TWX 910-443-2302

**CIRCLE NO 325**



## NEW! ADVANCED ACTIVE FILTER DESIGN SOFTWARE

Version 3.0 designs Lowpass, Highpass, Bandpass, Bandstop and ALLPASS filters with Butterworth, Chebyshev, elliptic and Bessel response ■ NOW calculates values for National MF-10, Reticon, MFB, VCVS, biquad and state variable filter circuits ■ Interactive graphics for group or phase delay, gain, phase, impulse and step response of the complete filter or individual section ■ Combine filters for system design/analysis ■ Modify circuits to observe effects (\$525) ■ for IBM PC, XT, AT, PS/2

### SPICE FILE CONVERSION OPTION AVAILABLE

RLM Research  
P.O. Box 3630  
Boulder, CO 80307-3630 (303) 499-7566

**CIRCLE NO 328**

## 68000 Single Board Computer

Complete system for stand-alone use  
or as an embedded controller.

68000 power at an eight bit price

- COMPLETE - 68000, 256K RAM, ROM, floppy control, SCSI, serial ports, parallel port.
- EXPANDABLE - RAM expandable to 512K, expansion bus for memory, I/O or special purpose expansion.
- VERSATILE - built in ROM monitor.
- COMPACT - only 5-3/4" x 8"
- ECONOMICAL - \$249.95.

**(213) 451-8910**

MARION SYSTEMS CORP.  
1317 Fifth Street, Suite 301  
Santa Monica, CA 90401

**CIRCLE NO 326**

## TIRED OF

- Net Lists That Won't Work.
- Autorouters That Don't Finish The Job.
- Multi-Layer PCs That Should Be Two Layers.
- Incomplete Parts List.

Save Time and Money!  
Get the Designer Back in the Loop  
and  
Get the Most Out of your Computer  
with the Best Manual Layout System  
on the Market!

Electronic Schematics .....	\$49.95
PC Layout (PC Sketch with Easy CAD)*39.95) .....	\$49.95
74000 Set A..74000-74199 .....	\$39.95
74000 Set B..74200-74649 .....	\$39.95
74000 Set C..74651 to End .....	\$39.95
4000/4500 CMOS .....	\$39.95
TOTAL .....	\$259.70

SPECIAL EDN PACKAGE PRICE! — \$199.00 for all of the above plus we'll include with the special package HOUSE PLANNER, a \$49.95 value at no charge, as our way of saying thanks.

or Complete EasyCAD Electronic Design System  
\$279.95

Specify CAD System: FastCAD, EasyCAD, Generic CAD, ProDesign II, Design CAD, CCS or AutoCAD.

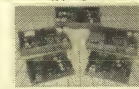
**800-433-2480**

CREATIVE  
CADD  
CONCEPTS, INC.  
Box 1919, Longmont, CO 80502-1919

**CIRCLE NO 329**

**TODD** MARKET SPECIFIC  
SWITCHING POWER SUPPLIES

Start Your Next OEM Product Design  
With A Power Supply Designed For Your Product



• 1500 customers in other OEM applications, manufacturing, research, medical, military, aerospace and other OEM applications. • 1500 customers in other OEM applications, manufacturing, research, medical, military, aerospace and other OEM applications. • 1500 customers in other OEM applications, manufacturing, research, medical, military, aerospace and other OEM applications.

**FREE!**  
Switching  
Power  
Supply  
Catalog

- Complete performance data for 46 multiple output switchers (160 to 700 watts), 16 single output switchers (150 to 520 watts; 5-48 volts) • Up to 31% smaller packages with power densities to 4 watts/in<sup>3</sup> for design flexibility • Organized for easy selection by recommended primary OEM product application.

For your free catalog, call 1-800-223-TODD, 516-231-3366, or write:

**TODD**  
PRODUCTS CORP.

50 Enjay Blvd., Brentwood, NY 11717

**CIRCLE NO 327**

## PAL®/EPLD PROGRAMMER

From  
\$689.00



Stand Alone/RS-232 Programs and Verifies  
20/24 pin PLDs from MMI, TI, National  
Cypress, Lattice, AMD, Altera  
PAL is a registered trademark of MMI.

*From A Name You Can Trust*

**LOGICAL DEVICES INC.**

1201 N.W. 65th Place  
Ft. Lauderdale, FL 33309

1-800-331-7766 (305) 974-0967  
Telex 383142 Fax (305) 974-8531

**CIRCLE NO 330**

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

# VOICE SCRAMBLING

Choose from 3 levels of security, with the only CMOS scramblers made. Analog for no-lag. Economical, high voice quality. Send for a FREE demo cassette of all 3 options from simple inverter to rolling code scrambler.

**MX-COM, INC.**

TOLL FREE 1-800-638-5577

# DROP-IN DUPLEX CVSD CODEC

Don't settle for the either-or codecs of Motorola and Harris. Spec the full-duplex MX609 and get simultaneous decode/encode, space-saving on-chip filters, 8 - 64 kb/sec. programmable sampling, and extended temp range.

# PACKET RADIO

For 1200 baud radio telemetry, remote data terminals, and packet radio, the full duplex MX519 Minimum Shift Key Modem offers high noise immunity, on-chip filtering, and easy  $\mu P$  interface. Now in both DIL and PLCC.

**MX-COM, INC.**

TOLL FREE 1-800-638-5577

**MX-COM, INC.**

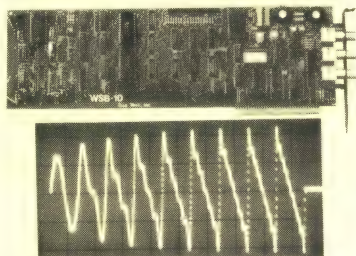
4800 Bethania Station Road • Winston-Salem, NC 27105-1201  
TOLL FREE 1-800-638-5577 • (919) 744-5050

CIRCLE NO 331

CIRCLE NO 332

CIRCLE NO 333

## WAVEFORM SYNTHESIZER



- For IBM-PC/XT/AT and compatibles
- Generates user-definable signal
- Up to 2000 points per envelope



**\$795.00**

478 E. Exchange St. Akron OH 44304  
(216) 434-3154 TLX: 5101012726  
1-800-553-1170

CIRCLE NO 334



### America's most advanced Personal Programmer

One programmer, one socket, one price, one thousand and one devices.

The most advanced firmware controlled pin driver system available means you never have to worry about buying another expensive module or PAK again. The "IO" Personal Programmer line offers the power and features comparable to many of the \$10,000 programmers, but at a fraction of the costs.

Support for CMOS, NMOS, ECL, Bipolar, PROMs, EPROMs, eEPROMs, PLDs, ePLDs, IFLs, FPLDs, up to 40 pin DIP packages

AMD, Atmel, Cypress, Excel, Fairchild, Fujitsu, GI, Hitachi, Hughes, Intel, Lattice, Mitsubishi, Motorola, National, NEC, MMI, Samsung, Seeg, Sierra, Signetics, SMOS, TI, Toshiba and Waterscale

Whatever your need is, Digital Media can help you solve it. And you won't believe how little it costs.

Call (714) 751-1373 to receive a complete product specification package immediately.

CIRCLE NO 335

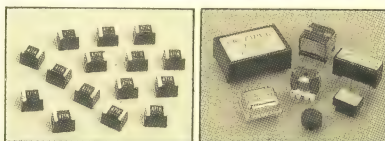
CIRCLE NO 336

## Join Forces

Combine your larger ads with EDN Product Mart ads for a total marketing program.

**EDN Product Mart**

## CHIP COILS DC-DC CONVERTERS PULSE TRANSFORMERS



Our Chip Coils is good for your miniaturization & surface mounting. DC-DC Converters, pulse transformers & band pass filters is now complete with excellent functions. We also supply choke coils, power chokes, linearity coils, toroidal coils, pulse transformers, coupling transformers, power transformers and others. Send for details today.!



OEM and Agent  
Inquiries Invited

**ABC TAIWAN ELECTRONICS CORP.**

No. 422, Sec. 1, Yang Fu Rd., Yangmei 32627,  
Taoyuan, Taiwan, R.O.C.

Tel: (03) 4788088, Telex: 32379 ABCEC

Fax: (03) 4755503

CIRCLE NO 338

## High quality and Prompt Delivery

Send in your special designs and specifications to Honlex, one of Taiwan's Leading Manufacturers.

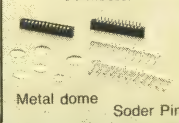
**HONLEX**



We offer:

1. Membrane Keyboard
2. Flexible printed circuit board
3. Plastic name plates and Labels
4. Connector, 2 pins to 24 pins.
5. Metal dome switch 6.0-13.0
6. Solder pins.

Connector



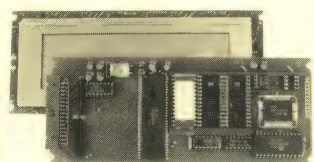
Metal dome Solder Pin

**HONLEX INDUSTRIAL CO., LTD.**

ADD: NO. 3, LANE 10, PIENG HO RD., CHUNG HO CITY TAIPEI HSIEN, TAIWAN, R.O.C.  
FAX: (02) 2253739 CABLE: "HSUCH" TAIPEI  
TEL: (02) 2253737-8 TELEX: 27722 JOENUNG

CIRCLE NO 339

## Heritage Systems Corporation



### HSC-9200 LCD Terminal/ SBC

240x64 dot graphic LCD controller  
ANSI X3.4 Terminal Firmware  
8 lines by 30 characters of text  
48 key (6x8 matrix) keypad encoder  
TTL or RS-232 Serial port to 9600  
Contrast adjusted from keypad  
3 memory sockets for RAM/ROM/EEPROM  
5v supply at 70mA with LCD Display  
180mm by 75mm card mounts to LCD  
HSC-9200 \$175/1 LCD \$85/1

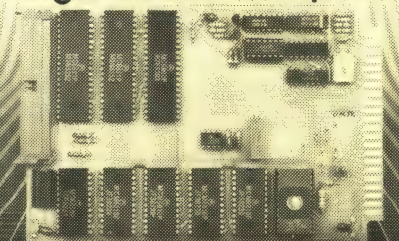
P.O. Box 10588  
Greensboro, NC 27404-0588  
(919) 274-4818

CIRCLE NO 337

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

# \$91.00\*

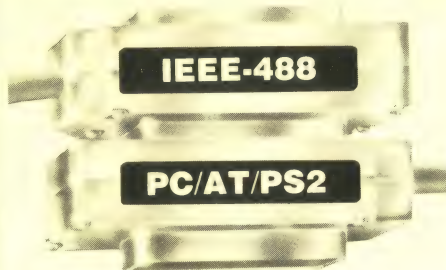
## Single Board Computer



\*500 piece price, model MCL45 (shown)  
6800 MPU, serial I/O, parallel I/O, RAM, EPROM,  
44-pin 4.5" x 6.5" PCB  
EXPANSION MODULES: RAM, EPROM, CMOS RAM/  
battery, analog I/O, serial I/O, parallel I/O, counter/  
timer, IEEE-488, EPROM programmer, floppy disks,  
cassette, breadboard, keyboard/display.



CIRCLE NO 340



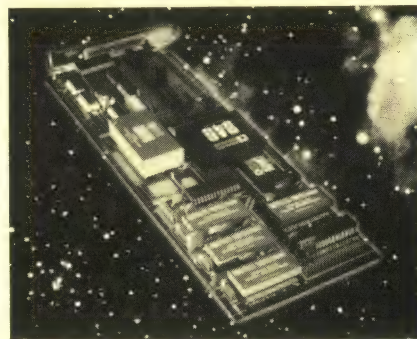
**GP-IB, HP-IB CONTROL FOR YOUR PC,  
PC/AT and IBM PERSONAL SYSTEM/2™**  
• Control instruments, plotters, and printers.  
• Supports BASIC, C, FORTRAN and Pascal.  
• Fast and easy to use. Thousands sold.  
• Software library. Risk free guarantee.



Capital Equipment Corp.  
99 South Bedford St.  
Burlington, MA. 01803

**FREE demo disk. Call (617) 273-1818**

CIRCLE NO 341



**18 BIT A/D CARD, PC COMPATIBLE**  
True 18 Bit A/D Resolution For Your PC or Com-  
patible • Programmable Resolution, Integration  
Time, Scan Rate and Data Format • Low Noise  
• Precision 16 Bit D/A • Four Signal Conditioning  
Blocks • External Interrupt Capabilities • Software  
has library of examples Using C • Assembly, Basic,  
Pascal, and Prolog also available. From \$850.

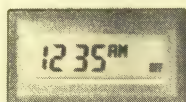
**Galiso Inc.**

4920 E. La Palma Ave., Anaheim, CA 92807  
714-779-8008

CIRCLE NO 342



CIRCLE NO 343



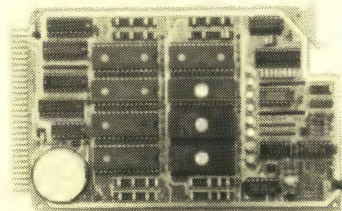
### Programmable Timers

The PTS27 and PTS31 LCD Timer Modules  
are an ideal replacement for microprocessor  
dedicated timers as well as mechanical time  
switches. With programming capabilities of up  
to three on/off time settings per day for the  
PTS31 and two on/off weekday, one Saturday  
and one Sunday time setting for the PTS27;  
they are both a cost effective approach to  
automating equipment and controls. Contact

**Dakota Digital**

RR5 Box 179E, Sioux Falls, SD 57107  
(605) 332-6513.

CIRCLE NO 344



### STD BUS 256K RAM/512 ROM BATTERY BACKED MEMORY CARD THE STD88301

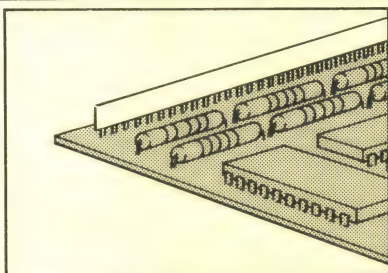
- 20-bit or 16-bit addressing
- Low power CMOS version available
- Processor independent
- 256 Kbyte RAM/512 Kbyte ROM capacity
- Accepts any mix of 8Kx8, through 64Kx8 ICs
- Individual starting addresses for each socket
- External inputs provide 8 Mbyte address space
- Selectable battery backed supply for each socket
- No wait states required for 8 Mhz 8088 CPUs
- "Bullet-proof" memory protection
- Socket by socket write protection
- Quantity 1 Price — \$225 without memory

Call TOLL FREE 1-800-521-0714 Ext. 229

**M.K. HANSEN COMPANY**

634 Industry Drive, Seattle, WA 98188

CIRCLE NO 345



### SAVE SPACE WITH MINI/BUS® BARS

Improve power distribution  
Reduce required board layers  
Eliminate up to half the decoupling  
capacitors  
Fit between or beneath IC's

**Send for Rogers Mini/Bus® Bars  
Application Bulletin.**

**Rogers Corp., 2400 S. Roosevelt St.  
Tempe, AZ 85282 602/967-0624**

CIRCLE NO 346

# 1,239,580 Filters

Lowest prices in America  
on small quantities

0.1 Hz to 500 MHz

1,239,580 standard filter  
types □ Miniature and  
subminiature sizes □  
Passive and active  
types □ Telemetry  
filters □ Gaussian,  
Butterworth, Cheby-  
shev designs □ Call  
or write for free  
catalog today.



TTE, Inc.,  
2233 South Barry Ave.,  
Los Angeles, CA 90064  
(213) 478-8224

**1,239,580  
STANDARD  
FILTER  
DESIGNS**



**FREE CATALOG**

CIRCLE NO 347



### NOW - MINIATURE AT QUARTZ CRYSTALS

- 32.0 MHz - 28.0 MHz - 24.0 MHz
- 20.0 MHz - 16.0 MHz - 14.328 MHz
- 12.0 MHz - 11.0592 MHz - 10.0 MHz
- SURFACE MOUNTABLE OR WITH LEADS
- MIL TEMP RANGE AVAILABLE
- RUGGED CERAMIC PACKAGING
- CLOSE TOLERANCE & LOW DRIVE CURRENT

**THE ONLY NAME YOU NEED TO REMEMBER IN QUARTZ  
CRYSTALS AND CRYSTAL OSCILLATORS IS STATEK!**

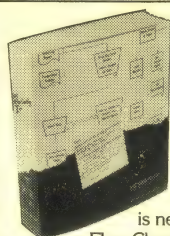


STATEK CORPORATION  
512 N. Main St., Orange, CA 92668  
(714) 639-7810

Made in the U.S.A. - Ship from stock

CIRCLE NO 348

To advertise in Product Mart, call Joanne Dorian, 212/463-6415



## Flow Charting II+ The New Plus for Fast Flowcharting

FLOW CHARTING  
is new! It's now

Flow Charting II+, with more speed  
+ more functions + more printing options;

- 10 text fonts; 26 shapes; • Line mode can stop at a shape; • Backspace key can erase a line to its origin; • Free text entry anywhere, or select auto-centering; • Vertical or horizontal printing; one chart or multiple charts.

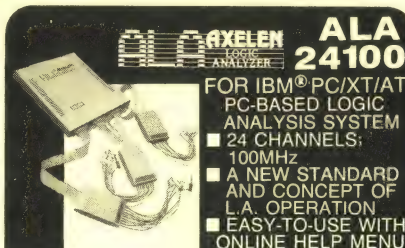
Used by Fairchild, Bechtel and more than 500 other major corporations. Edit quickly and accurately — even major edits — with Flow Charting II+, the Specialist.

See your retail store or call:

**PATTON & PATTON**

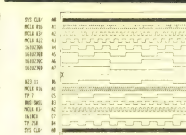
Software Corporation  
800/672-3470, ext. 897 California  
800/538-8157, ext. 897 National  
408/629-5044 International)

CIRCLE NO 349



**ALA AXELEN 24100**  
FOR IBM® PC/XT/AT  
PC-BASED LOGIC  
ANALYSIS SYSTEM  
■ 24 CHANNELS;  
100MHz  
■ A NEW STANDARD  
AND CONCEPT OF  
E.A. OPERATION  
■ EASY-TO-USE WITH  
ONLINE HELP MENU

- 8CH at 100MHz 8176 bits/CH
- 24CH at 25MHz 2044 bits/CH
- FOUR LEVELS SEQUENTIAL TRIGGER
- MORE THAN 4,000 COMBINATIONS OF TRIGGER CONDITIONS
- DATA QUALIFICATION TO RECORD ONLY EVENTS OF INTEREST
- FAST SCROLLING AND PAGING
- QUICK SEARCH AND LOCATE FEATURE
- BIN/OCT/HEX/ASCII DISPLAY BASE
- HARD COPY



AGENT WANTED! AGENT WANTED! AGENT WANTED!

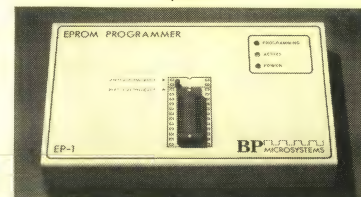


**AXELEN INDUSTRIAL INC.**

P.O. BOX 24-650 Taipei Taiwan R.O.C.  
FAX: 886-2-7529768 • Tlx: 10305 AXELEN  
Tel: 886-2-7529819/7714867

CIRCLE NO 350

## EPROM PROGRAMMER \$349



THE EP-1's A GREAT VALUE & HERE'S WHY:

- READS, PROGRAMS, COPIES OVER 300 EPROMS AND EEPROMS FROM 29 MANUFACTURERS INCLUDING 2716-27513, 2804-28256, 27011
- READS & WRITES INTEL, MOTOROLA, STRAIGHT HEX AND BINARY
- OPTIONAL HEADS PROGRAM INTEL 874X, 8751, 87C51, 8752, 8755
- MENU-DRIVEN CHIP SELECTION BY MFG & P/N; NO MODULES
- FAST, SLOW, QUICK PULSE PROGRAMMING ALGORITHMS
- SPLITS FILES BY BASE ADDRESS AND ODD/EVEN (16&32 BIT)
- ALL INTELLIGENCE IN UNIT; 280 MICROPROCESSOR BASED
- 5, 12.5, 21, 25 VOLT PROGRAMMING FOR CMOS AND -A SUFFIX PARTS
- FREE PC-DOS SOFTWARE
- GOLD TEXTOL ZIF SOCKET
- SAME DAY SHIPMENT
- ONE YEAR WARRANTY
- MONEY-BACK GUARANTEE
- RS232 TO ANY COMPUTER
- 8 BAUD RATES TO 38,400
- GENERATES, CHECKS CHECKSUMS
- TWO FREE FIRMWARE UPDATES
- UV ERASERS FROM \$34.95

CALL TODAY FOR MORE INFORMATION

**BP MICROSYSTEMS**

800/225-2102 713/461-9430 TELEX 1561477  
10681 HADDINGTON #190 HOUSTON, TX 77043

CIRCLE NO 751

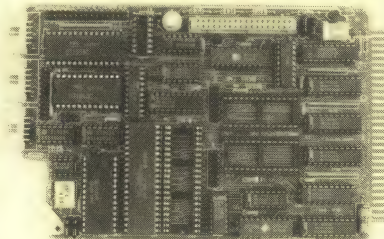


## IMPROVE BOARD PERFORMANCE

MICRO/Q capacitors can be retrofitted to solve noise problems on existing boards. Because MICRO/Q caps share mounting holes with existing IC pins no board redesign is required.

Effective decoupling becomes a matter of adding one insertion step. **Rogers Corp.**, 2400 S. Roosevelt St., Tempe, AZ 85282. 602/967-0624

CIRCLE NO 752



## CMOS 80C88 SINGLE BOARD STD BUS COMPUTER

Features the 16-bit 8088 with 8087 coprocessor socket and 1 Mbyte addressing. On-board functions include 2 JEDEC 28-pin memory sockets for up to 128K bytes of RAM, EPROM, or EEPROM. Includes one RS-232/RS-422 serial port, 8259A interrupt controller, 3 16-bit counter/timers, SBX connector, and Watchdog timer. Available in NMOS/TTL or CMOS from

**WinSystems, Inc.**  
PO Box 121361  
Arlington, TX 76012  
817/274-7553

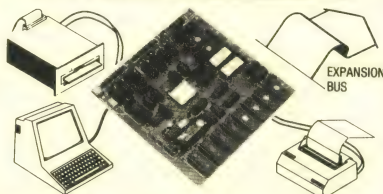
CIRCLE NO 753

## Small Space Advertising For Big Results

EDN Product Mart

CIRCLE NO 754

## OEM188 SBC DEVELOPMENT SYSTEM FOR PRODUCT APPLICATIONS



The OEM188 - designed to bring your product to market in the fastest possible time - through the most productive software development environment available & cost effective hardware.

- The OEM188 boots MS-DOS or CP/M-86. Write your program in Assembler, Forth, Basic, C, Fortran or Pascal.
- ROM your code. The EPROM programmer is onboard and fully integrated into the hardware and software.
- Develop your code quickly with Vesta's ROMmed languages designed for control tasks.

Size 8" x 8". FDC for 4 drives, Dual UART with RS-232, TTL and RS-422 I/O, Bus - IBM, Printer port, Watchdog, Battery backed real time clock and up to 256 K static RAM/ROM. Programmer interface - terminal. Various I/O boards available.

Prices starting as low as \$329 each

**VESTA TECHNOLOGY, INC.** • 7100 W. 44th Ave. • Suite 101  
Wheatridge, CO 80033 • (303)422-8088 • VISA & MC

CIRCLE NO 755



## E(P)ROM PROGRAMMER \$495

- Built in Timer Eraser option (\$50); Foam pad;
- No personality modules; Menu selection of devices;
- User friendly software; Complete help menu;
- Direct technical support; Full 1 year warranty;
- Stand alone duplication & verify (24/28 pins);
- Quick pulse algorithm (27256 under 60 sec);
- All 24/28 pin parts to 1 Mbit; CMOS, EEPROMS;
- 8741, -2, -4, -8, -8H, -9, -9H, -51, -52, -55, 9761 & more
- IBM-PC, Apple, CPM or Unix driver; Autobaud RS232;
- Offset/split Hex, Binary, Intel & Motorola 8, 16, 32 bit;
- Kits from \$95. Manual with complete schematics.

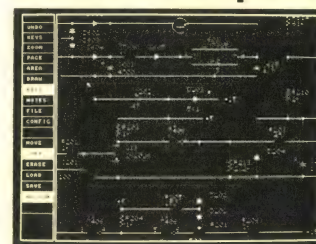
Call today for datasheets!!

**B&C MICROSYSTEMS**

355 WEST OLIVE AVE., SUNNYVALE, CA 94086  
Ph: (408) 730-5511 VISA & MC

CIRCLE NO 756

## SCHEMA II Schematic Capture



## FREE Demo Disk: 1-800-553-9119

SCHEMA's success is the talk of the CAE industry and thousands of satisfied SCHEMA owners know why. Incredible speed, ease of use, and power have made SCHEMA a best-selling schematic capture program for engineering professionals the world over.

Now, SCHEMA II is available.

SCHEMA II sells for \$495 and supports most common IBM PC/XT/AT configurations. Please call today for a free SCHEMA II demo disk.



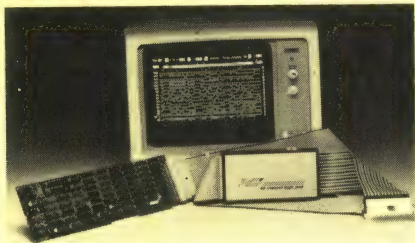
**OMATION**

In Texas Call (214) 231-5167

CIRCLE NO 757

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

## 25MHz 48 CHANNEL PC-BASED LOGIC ANALYZER \$1595.00



48 Channels @25MHz x 4K word deep  
16 Trigger words/16 trigger sequence  
Automatic set-up and loading of symbol tables  
Symbolic disassembly of microprocessors  
Storage and recall of trace data to disk  
65K Pass/Delay Counter  
16 Channel Waveform Display  
Disassembles available for:

8088	Z80	6801
8086	8085	6303
68000	6502	8031

NCI

6438 UNIVERSITY DRIVE  
HUNTSVILLE, AL 35806  
(205)837-6667

CIRCLE NO 785



## Great Designs Start With Tango-Schematic.™ Just \$495.

Designs quickly come to life with Tango-Schematic's easy-to-use drawing editor and extensive component libraries. Features four line types, four text sizes, repeat and block functions, unique built-in word processor. Includes DRC, BOM, Wire List, Net List outputs and crisp plots, prints, or laserprints. The perfect front end to our popular Tango-PCB and Tango-Route board design systems.

For IBM PC/XT/AT/PS2. Just \$495. Full-function Demo Package: \$10. Order toll-free 800 433-7801. VISA/MC. Thirty-day money back guarantee.

ACCEL Technologies, 7358 Trade St., San Diego, CA 92121  
Outside N., S. America contact HST Technology (Australia)  
Phone: 61-02-34-8499 FAX: 61-02-23-8771

CIRCLE NO 786



## Glide Through PCB Design.

**TangoPCB™** Create the toughest board designs with powerful layout software that's a snap to use. Function-rich Tango-PCB supports eight layers, 1 mil grid, OrCAD™ or Schema™ netlist input, print/plot/photoplot output, and more.

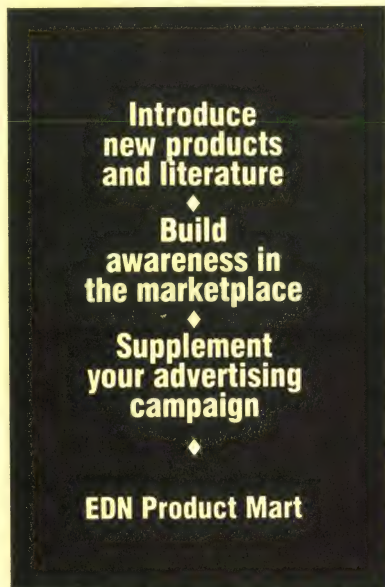
**TangoRoute™** Get impressive completion rates and remarkable speed with Tango-Route, a four layer, eleven pass autorouter.

**Just \$495 each.**

For IBM PC/XT/AT/PS2. Compare features and you'll buy Tango. Or try full-function Demo Package, just \$10. Order toll-free: 800 433-7801. VISA/MC. Thirty-day money back guarantee.

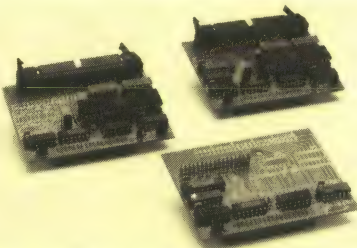
ACCEL Technologies, 7358 Trade St., San Diego, CA 92121

CIRCLE NO 786



CIRCLE NO 788

## SBX MODULES

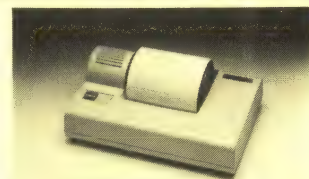


We've upgraded our SBSxSCSI module to support Block-Mode Pseudo-DMA transfers. That means CPUs without DMA can increase transfer speeds by not polling for READY on every byte. We've also added an optional Centronics-compatible printer port (SBSxSCSI/CEN). If you only need the printer port, save money with our low-cost SBSxCEN module. We also offer a Floppy-Disk Controller module (SBSxFDC) that handles 3½", 5¼", and 8" drives with SD, DD and HD formats.

Call or write for more information.

Single Board Solutions, Inc.  
20045 Stevens Creek Blvd.  
Cupertino, CA 95014  
(408) 253-0250

CIRCLE NO 789



## ALPHACOM 42®

The ideal printer for **MEDICAL, SCIENTIFIC** and **INDUSTRIAL INSTRUMENTATION**.

- Fast - 2 lines/sec.
- Quiet - Thermal Dot Matrix Printing
- Low Cost - Less than \$125 in OEM quantity
- Plug-In Interface for Serial or Parallel

Alphacom® is a Trade Name of  
**BROWN KELLOGG, INC.**

2108-C Bering Drive  
San Jose, CA 95131  
(408) 436-0801

CIRCLE NO 790

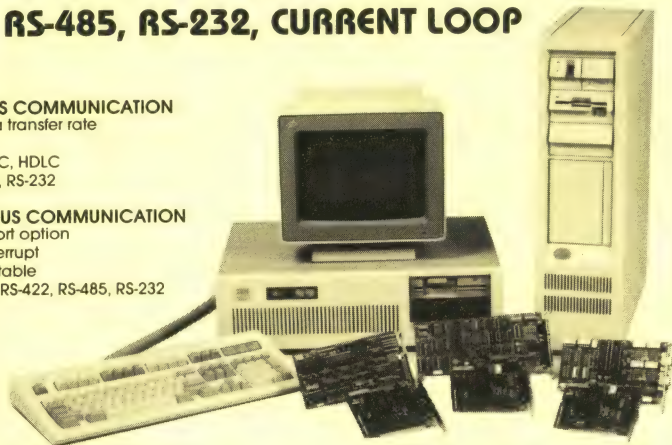
# SYNCHRONOUS/ASYNCHRONOUS RS-422, RS-485, RS-232, CURRENT LOOP

## SYNCHRONOUS COMMUNICATION

- 1 Mbaud data transfer rate
- DMA facility
- Byte sync, SDLC, HDLC
- RS-422, RS-485, RS-232

## ASYNCHRONOUS COMMUNICATION

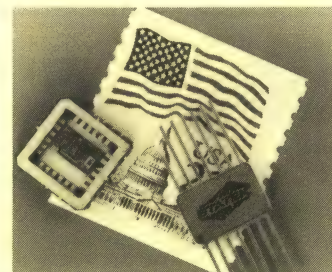
- Single/dual port option
- Selectable interrupt
- Address selectable
- Current Loop, RS-422, RS-485, RS-232



Leaders in Communication Technology

TOLL FREE: 1-800-553-1170  
478 E. Exchange St. Akron, Ohio 44304  
(216)434-3154 TLX:5101012726 FAX:(216)434-1409

CIRCLE NO 792



## NOW - THE SXO CRYSTAL OSCILLATOR

- 24 PIN CLCC OR TO-5
- CMOS OR TTL COMPATIBLE HYBRID CIRCUIT
- SIZE ONLY .4" x .4" x .06"
- MIL TESTING AVAILABLE
- FREQUENCY RANGE OF 10 kHz to 2 MHz
- SHOCK RATING IS 250g to 5,000g
- LASER TUNING AFTER ASSEMBLY

THE ONLY NAME YOU NEED TO REMEMBER IN QUARTZ CRYSTALS AND CRYSTAL OSCILLATORS IS STATEK!



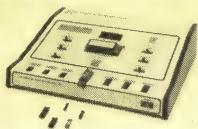
STATEK CORPORATION  
512 N. Main St., Orange, CA 92668  
(714) 639-7810

Made in the U.S.A.

CIRCLE NO 793

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

## THE BETTER RAM TESTER



**WITH BETTER  
COST/PERFORMANCE**

### IST Model 6400 ADVANTAGES:

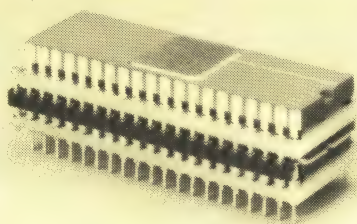
- Tests most Static RAMs or DRAMs up to 1Mbit.
- Automatically rejects any out-of-tolerance device (in power consumption or speed) by testing operating current and access time.
- A software controlled edge deskew procedure generates the most precise timing waveforms for DRAMs testing.
- Tests function with a group of specialized test patterns to detect all possible faults.
- Interface to automatic IC handlers with front panel control sorting capability.
- Stand alone or slave to a terminal or computer (via RS-232C) for detailed test result display or failure analysis.
- Modular architecture eliminates set-up time when changing over from one device to another.
- Low cost/high performance with one-year warranty. Price: \$2,500.



487 Gianni Street  
Santa Clara, CA 95054  
FAX: (408) 980-1794  
TELEX: 372 4348 INFO SCAN

**FOR LOW COST/  
HIGH PERFORMANCE, call:  
(408) 988-1908**

**CIRCLE NO 776**



### MATH COPROCESSOR ADAPTER SOCKET

The 8087 Stak Pak allows an 8087 math coprocessor to be installed in 8088 and 8086 based microcomputers that do not have a built in coprocessor socket.

#### FEATURES

- Only .65 inches high with 8087 installed
- Compatible with most 8088/86 based microcomputers
- Allows field replacements of 8088/86 and 8087
- High mechanical stability
- Doesn't overhang other board components
- Quantity 1 Price — \$50 without ICs

Call TOLL FREE 1-800-521-0714 Ext. 229

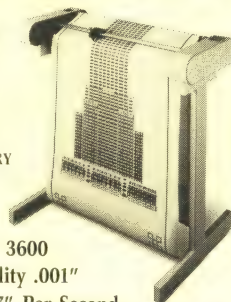
**M.K. HANSEN COMPANY**  
634 Industry Drive, Seattle, WA 98188

**CIRCLE NO 777**

## "D" SIZE PLOTTER

**\$2295<sup>00</sup>  
RETAIL**

**\$1695<sup>00</sup>  
INTRODUCTORY  
OFFER**



- Model PC 3600
- Repeatability .001"
- Speed at 7" Per Second
- Vacuum Paper Hold Down
- High Resolution Circles: Suitable for PCB Artwork

**(415) 490-8380 ZERICON**

4423 ENTERPRISE ST. • FREMONT, CA 94538

**CIRCLE NO 778**



**smARTWORK® PCB Software.** In a fraction of the time hand taping requires, you can create double-sided printed-circuit boards with smARTWORK and your IBM PC. The program's features include continual design-rule checking, automatic pad shaving, a silkscreen, and text for all three layers. **smARTWORK** with autorouting is \$895 (without, \$495) and comes with a 30-day money-back guarantee. Credit cards accepted. Write or call

### Wintek Corporation

1801 South Street, Lafayette, IN 47904  
(800) 742-6809 or (317) 742-8428

**CIRCLE NO 779**

## DATA LINK ANALYZER



Turn your personal computer into an ASYNC DATA LINK ANALYZER at a fraction of the cost of buying one.

- Operates on IBM PC/XT/AT or compatibles
- Configurable to all standard PARITY, STOP BITS, and BAUD RATES up to 9600 baud each way, full duplex
- Programmable trigger sequences
- Can store and display up to 32k characters
- Totally passive — no insertion effect
- Data can be stored as DOS files. Use standard utilities to manipulate and process the data — or write your own

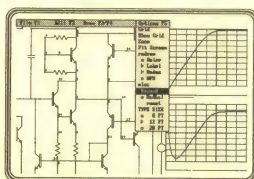
LINK-VIEW: \$125.00



**Sytel Information Systems, Inc.**  
44 Netto Lane, Plainview, NY 11803  
(516) 933-2130

**CIRCLE NO 782**

## Analog Circuit Simulation



**NEW  
SPICE\_NET  
\$295.00**

Make SPICE input files from schematic drawings using pull down menus and a mouse to draw and connect parts. Use an IBM PC with any UC Berkeley compatible SPICE program.

### Simulation Programs

for

**IBM  
PC's  
from  
intusoft**

- **IS SPICE, \$95.00.** Performs AC, DC and Transient analysis.

- **PRE SPICE \$200.00:** Adds Monte Carlo Analysis, Sweeps, Optimization, libraries and algebraic parameter evaluation.

- **Intu\_Scope \$250:** A graphics post processor works like a digital oscilloscope. Easy to use with all the waveform operations you will ever need.

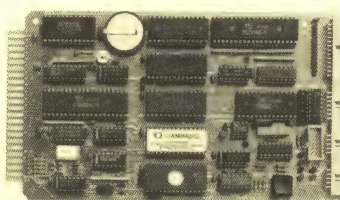
(213) 833-0710

P.O. Box 6607  
San Pedro, CA  
90734-6607

**CIRCLE NO 780**

**NEW**

## CMOS CONTROL COMPUTER



**SBS-1000** has turbo speed, 20K industrial BASIC. Runs 5 times faster than BASIC-52 systems. All CMOS with Z80 CPU, EPROM/EEPROM programmer, 96K static RAM, 2 RS-232C serial ports, 32 lines digital I/O, 4 channels-12 bit A/D, battery backed calendar clock, keypad and display ports, expansion port, autorun mode, interrupts handled by BASIC, industrial quality, 5V and stand alone operation. From **\$396** in 100s.

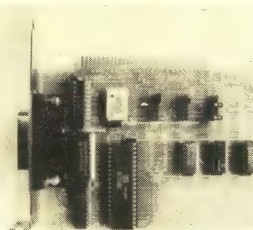
For Immediate Response: **303-426-8540**



**OCTAGON SYSTEMS  
CORPORATION**

6510 W. 91st Ave.  
Westminster, CO 80030

**CIRCLE NO 783**



**IEEE488 \$145  
LOW COST PC/XT/AT INTERFACE  
FOR IEEE-488 (GPIB/HPIB)**

- SHORT CARD FOR PC/AT/XT & COMPATIBLES
- 1 OF 6 INTERRUPT LEVELS
- 1 OF 2 DMA CHANNELS
- UP TO 4 BOARDS/COMPUTER
- CONTROLLER/TALKER/LISTENER
- QUANTITY DISCOUNTS
- COMPATIBLE WITH MOST SOFTWARE PACKAGES

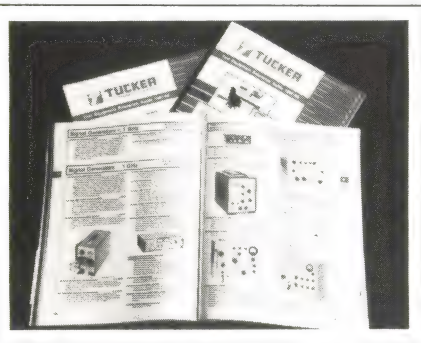
Call today for datasheet!

### B&C MICROSYSTEMS

355 West Olive Ave., Sunnyvale, CA 94086  
Ph: (408)730-5511 Fax: (408)730-5521 Visa & MC

**CIRCLE NO 784**

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

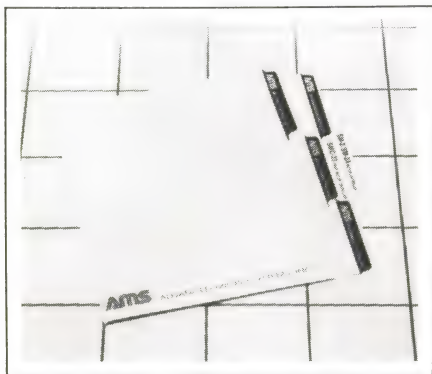


## Comprehensive guide categorizes test equipment

*The Test Equipment Reference Guide 1987/1988* is a 375-pg catalog that contains technical specifications and prices for more than 4000 reconditioned test instruments, as well as new instruments, power supplies, coaxial components, waveguides and waveguide components, and a line of technical books. Many items are available for short-term rental or lease. The equipment categories include amplifiers, analyzers, avionics and telecommunications test equipment, frequency-measuring instruments, generators, bridges, calibration and standards, meters, oscilloscopes, power supplies, RFI/EMI, and microwave components.

**Tucker Electronics Co., Box 461966, Garland, TX 75046.**

**Circle No 404**



## Guide covers motion-control and vision systems

This 1988 product guide presents data and prices for the vendor's single-board computers, memory I/O cards, intelligent motor-controller ICs/boards, dual-axis chopper de-

sign, and intelligent motor-controller boards/systems. Also included are high-power driver cards, video cross-hair generators/digitizers, programmable cross-hair generators, high-speed data-acquisition boards, digital speech generators, and an intelligent motor-controller board for the IBM PC/XT and PC/AT.

**Advanced Micro Systems Inc, 31 Flagstone Dr, Hudson, NH 03051.**

**Circle No 405**



## Test-equipment catalog

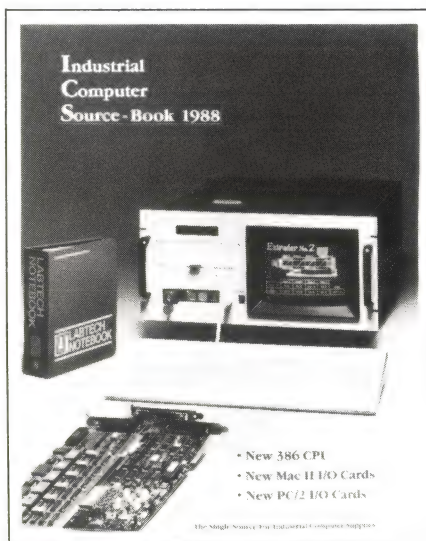
This 8-pg catalog describes the company's complete line of products, featuring new multifunction frequency counters and 2-MHz sweep/function generators. Other products featured are 3½- and 4½-digit handheld DMMs; a VOM (voltmeter, ohmmeter, ammeter); a high-accuracy, full-range 3½-digit capacitance tester; and a variety of other digital instruments and probes.

**Mercer Electronics, 859 Dundee Ave, Elgin, IL 60120.**

**Circle No 406**

## Expanded list of products for IBM PCs

The 1988 *Industrial Computer Source-Book* features products for industrial and educational laboratories, factory automation, and pro-



cess measurement and control. The product offerings now include new 386 CPU cards, CMOS I/O cards, data-acquisition and -control products for VME Bus computers, Apple MACII A/D I/O cards, and PS/2 I/O cards. A variety of industrial computers, equipment, and components are available, as well as a large selection of 19-in. rack-mount accessories, including a rack-mount industrial PC/AT, keyboard, printer, and monitor. Further, a new 34-pg software section, as well as more than 120 updated scientific- and engineering software packages have been added.

**Industrial Computer Source, 5466 Complex St, Suite 208, San Diego, CA 92123.**

**Circle No 407**

## Data-collection products presented

This 16-pg catalog features the vendor's DataQuest line of data terminals, transaction processors, automatic identification interfaces, and peripherals. It presents the key features, applications, benefits, and ordering information for each product. Illustrations and diagrams, as well as lists of the vendor's domestic and international offices, complete the brochure.

**Burr-Brown Corp, Box 11400, Tucson, AZ 85734.**

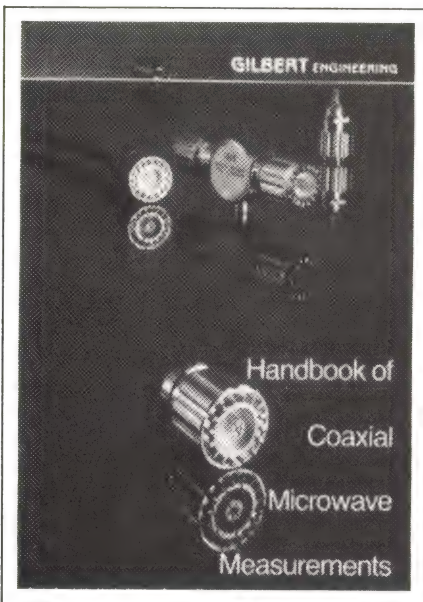
**Circle No 408**

## Science- and engineering-software aids discussed

*Lifeboat*, a scientific- and engineering software guide, describes 100 packages designed for use in solving equations, analyzing data, breaking down numbers, and designing 3-D CAD/CAM. The products are listed side by side to make it easier for you to compare them and make a selection. The product categories include circuit design, embedded systems, data acquisition/signal analysis, languages/utilities, Basic, C, cross-assemblers, and Fortran.

**Lifeboat Associates Inc.**, 55 S Broadway, Tarrytown, NY 10591.

Circle No 409



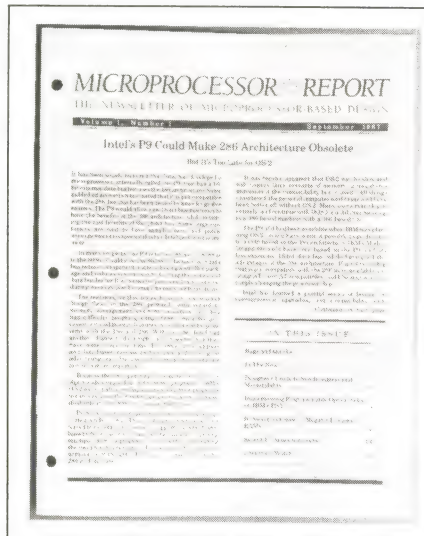
## Handbook deals with microwave measurements

The 163-pg *Handbook of Coaxial Microwave Measurements* examines the theory behind microwave measurements and coaxial TEM (transverse electromagnetic wave) transmission lines. It includes chapters on traveling and standing waves, the Smith Chart, 2-port devices, discontinuities, general theory, and some laboratory-measurement equipment setups. It augments current manuals on automatic network analyzers by probing more deeply into microwave-measurement the-

ory. It costs \$10, but is available at no charge to qualifying professionals.

**Gilbert Engineering**, Box 23189, Phoenix, AZ 85063.

INQUIRE DIRECT



## Newsletter for microprocessor designers

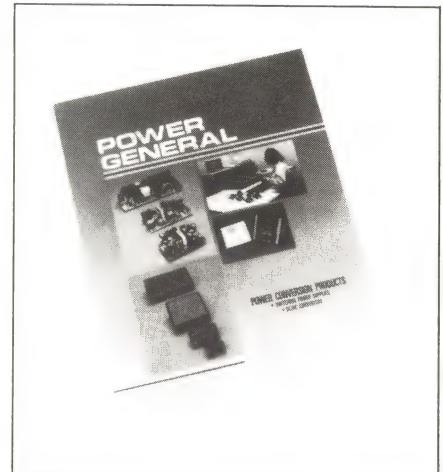
Written exclusively by design engineers, the monthly newsletter *Microprocessor Report* addresses the needs and concerns of designers of  $\mu$ P-based hardware. It focuses on design techniques, product evaluation, and development tools for  $\mu$ P-based design. It includes product descriptions, analysis, circuit examples, and bug reports. A monthly index of the most significant articles in journals and trade magazines, as well as design techniques for IBM's Micro Channel and Apple's Nubus, are regular features. The subscription rate is \$195/year, but for a limited time a charter subscription rate of \$135/year is available.

**MicroDesign Resources Inc.**, 230 California Ave, Palo Alto, CA 94306.

INQUIRE DIRECT

## DC-DC converter handbook

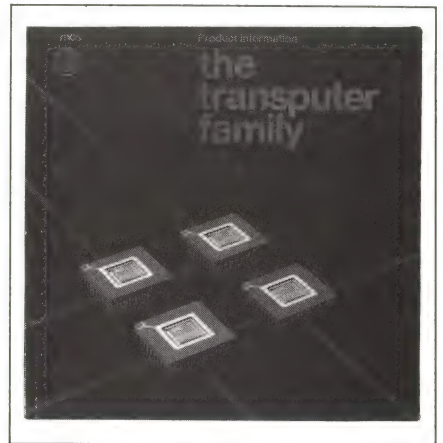
This 144-pg handbook presents the vendor's complete line of switching power supplies and dc/dc converters. Selection tables provide product descriptions and engineering



data on all models. The catalog contains glossaries of power-supply terminology, information about power-supply theory of operation, and application notes.

**Power General**, Box 189, Canton, MA 02021.

Circle No 412



## Transputer family delineated

This 126-pg booklet, *The Transputer Family*, provides an overview of the products that comprise the Transputer family. They include Transputers, development systems, and evaluation boards. Illustrations and diagrams are also included.

**Inmos Corp.**, Box 16000, Colorado Springs, CO 80935.

Circle No 413

## EDN's CHARTER

EDN is written for professionals in the electronics industry who design, or manage the design of, products ranging from circuits to systems.

EDN provides accurate, detailed, and useful information about new technologies, products, and design techniques.

EDN covers new and developing technologies to inform its readers of practical design matters that will be of concern to them at once or in the near future.

EDN covers new products

- that are immediately or imminently available for purchase
- that have technical data specified in enough detail to permit practical application
- for which accurate price information is available.

EDN provides specific "how to" design information that our readers can use immediately. From time to time, EDN's technical editors undertake special "hands-on" projects that demonstrate our commitment to readers' needs for useful information.

EDN is written by engineers for engineers.

# EDN

275 Washington St  
Newton, MA 02158  
(617) 964-3030

**F Warren Dickson**  
Vice President/Publisher  
Newton, MA 02158  
(617) 964-3030  
Telex 940573  
Diann Siegel, Assistant

**Peter D Coley**  
VP/Associate Publisher/  
Advertising Sales Director  
Newton, MA 02158  
(617) 964-3030  
Ora Dunbar, Assistant/Sales Coordinator

**NEW ENGLAND**  
John Bartlett, Regional Manager  
Chris Platt, Regional Manager  
199 Wells Ave  
Newton, MA 02159  
(617) 964-3730

**STAMFORD 06904**  
George Isbell, Regional Manager  
8 Stamford Forum, Box 10277  
(203) 328-2580

**NEW YORK, NY 10011**  
Daniel J Rowland, Regional Manager  
249 West 17th St  
New York, NY 10011  
(212) 463-6419

**PHILADELPHIA AREA**  
Steve Farkas, Regional Manager  
487 Devon Park Dr  
Suite 206  
Wayne, PA 19087  
(215) 293-1212

**CHICAGO AREA**  
Clayton Ryder, Regional Manager  
Randolph D King, Regional Manager  
Cahners Plaza  
1350 E Touhy Ave, Box 5080  
Des Plaines, IL 60017  
(312) 635-8800

**DENVER 80206**  
John Huff, Regional Manager  
44 Cook St  
(303) 388-4511

**DALLAS 75243**  
Don Ward, Regional Manager  
9330 LBJ Freeway  
Suite 1060  
(214) 644-3683

**SAN JOSE 95128**  
Walt Patstone, Regional Manager  
Bill Klanke, Regional Manager  
Philip J Branon, Regional Manager  
James W Graham, Regional Manager  
3031 Tisch Way, Suite 100  
(408) 243-8838

**LOS ANGELES 90064**  
Charles J Stillman, Jr  
Regional Manager  
12233 W Olympic Blvd  
(213) 826-5818

**ORANGE COUNTY/  
SAN DIEGO 92715**  
Jim McErlean, Regional Manager  
18818 Teller Ave, Suite 170  
Irvine, CA  
(714) 851-9422

**PORTLAND, OREGON 97221**  
Pat Dakin, Regional Manager  
Walt Patstone, Regional Manager  
1750 SW Skyline Blvd, Box 6  
(503) 297-3382

**UNITED KINGDOM/BENELUX**  
Jan Dawson, Regional Manager  
27 Paul St  
London EC2A 4JU UK  
01-628 7030  
Telex: 914911; FAX: 01-628 5984

**SCANDINAVIA**  
Stuart Smith  
27 Paul St  
London EC2A 4JU UK  
01-628 7030  
Telex: 914911; FAX: 01-628 5984

**FRANCE/ITALY/SPAIN**  
Alasdair Melville  
27 Paul St  
London EC2A 4JU UK  
01-628 7030  
Telex: 914911; FAX: 01-628 5984

**WEST GERMANY/SWITZERLAND/AUSTRIA**  
Wolfgang Richter  
Sudring 53  
7240 Horb/Neckar  
West Germany  
49-7451-7828; TX: 765450

**ISRAEL**  
Igal Elan  
Elan Marketing Group  
13 Haifa St, Box 33439  
Tel-Aviv, Israel  
Tel: 972-3-268020  
TX: 341667

**EASTERN BLOC**  
Uwe Kretzschmar  
27 Paul St  
London EC2A 4JU UK  
01-628 7030  
Telex: 914911; FAX: 01-628 5984

**FAR EAST**  
Ed Schrader, General Manager  
18818 Teller Ave, Suite 170  
Irvine, CA 92715  
(714) 851-9422; Telex: 183653

**TOKYO 160**  
Kaoru Hara  
Dynaco International Inc  
Suite 1003, Sun-Palace Shinjuku  
8-12-1 Nishishinjuku, Shinjuku-ku  
Tokyo 160, Japan  
Tel: (03) 366-8301  
Telex: J2322609 DYNACO

**TAIWAN**  
Acteam International  
Marketing Corp  
6F, No 43, Lane 13  
Kwang Fu South Rd  
Mailing Box 18-91  
Taipei, Taiwan ROC  
760-6209 or 760-6210  
Telex: 29809  
FAX: (02) 7604784

**KOREA**  
BK International  
Won Chang Bldg, 3rd Floor 26-3  
Yoido-dong, Youngdungpo-ku  
Seoul 150, Korea  
Tel: 785-6665  
Fax: 784-1915  
Telex: K32487 BIZKOR

**PRODUCT MART**  
Joanne Dorian, Manager  
249 West 17th St  
New York, NY 10011  
(212) 463-6415

**CAREER OPPORTUNITIES/  
CAREER NEWS**  
Roberta Renard  
National Sales Manager  
103 Eisenhower Parkway  
Roseland, NJ 07068  
(201) 228-8602

Janet O Penn  
Eastern Sales Manager  
103 Eisenhower Parkway  
Roseland, NJ 07068  
(201) 228-8610

Dan Brink  
Western Sales Manager  
18818 Teller Ave  
Suite 170  
Irvine, CA 92715  
(714) 851-9422

Maria Cubas  
Production Assistant  
(201) 228-8608

**Cahners Magazine Division**  
William Platt, Chief Executive Officer  
Terry McDermott, President  
Frank Sibley, Group Vice President  
Tom Dellamaria, VP/Production & Manufacturing

**Circulation**  
Denver, CO: (303) 388-4511  
Sherri Gronli, Group Manager  
Eric Schmierer, Manager

Reprints of EDN articles are available on a custom printing basis at reasonable prices in quantities of 500 or more. For an exact quote, contact Joanne R Westphal, Cahners Reprint Service, Cahners Plaza, 1350 E Touhy Ave, Box 5080, Des Plaines, IL 60018. Phone (312) 635-8800.

# CAREER OPPORTUNITIES

## 1988 Editorial Calendar and Planning Guide

**EDN**

Editorial Emphasis

EDN News

Issue Date	Recruitment Deadline		
Feb. 4	Jan. 14	Semicustom ICs, Computers & Peripherals	
Feb. 18	Jan. 28	Materials & Hardware, CAE, Power Sources	Closing: Jan. 21 Mailing: Feb. 11
Mar. 3	Feb. 11	Communications, CAE, High-Speed Logic	
Mar. 17	Feb. 25	Graphics, Filters, Software/CAE	Closing: Mar. 3 Mailing: Mar. 24
Mar. 31	Mar. 10	Power Semiconductors, Memory/Graphics, Fiber Optics	
Apr. 14	Mar. 23	Communication Technology Special Issue, Communication Systems	Closing: Mar. 31 Mailing: Apr. 21
Apr. 28	Apr. 7	Software, Industrial Computers, Interface ICs	
May 12	Apr. 21	Analog Technology Special Issue, Analog Converters	Closing: Apr. 28 Mailing: May 19
May 26	May 5	CAE, Software, Sensors/Transducers	
June 9	May 19	CAE, Analog ICs, Test & Measurement	Closing: May 29 Mailing: June 16
June 23	June 2	Data Communications, DSP, Components	
July 7	June 14	Product Showcase—Vol. I, Power Sources, Software	Closing: June 23 Mailing: July 14
July 21	June 30	Product Showcase—Vol. II, CAE, Test & Measurement	
Aug. 4	July 14	Sensors & Transducers, Analog ICs, Graphics	Closing: July 21 Mailing: Aug. 11
Aug. 18	July 28	Military Electronics Special Issue, Displays, Military ICs	
Sept. 1	Aug. 11	Instruments, Op Amps, Computers & Peripherals	Closing: Sept. 1 Mailing: Sept. 22
Sept. 15	Aug. 25	Data Acquisition, Data Communications, Digital ICs	
Sept. 29	Sept. 8	DSP, Graphics, Optoelectronics	Closing: Sept. 29 Mailing: Oct. 20
Oct. 13	Sept. 22	Test & Measurement Special Issue, Instruments, Computers & Peripherals	
Oct. 27	Oct. 6	CAE, Computers & Peripherals, Integrated Circuits, Wescon '88 Show Preview	Closing: Oct. 27 Mailing: Nov. 17
Nov. 10	Oct. 20	Programmable Logic Devices, Integrated Circuits, Test & Measurements, Wescon '88 Show Issue	
Nov. 24	Nov. 3	Microprocessor Technology Directory Graphics, CAE	Closing: Nov. 21 Mailing: Dec. 15
Dec. 8	Nov. 16	Product Showcase—Vol. I, Power Sources, Software	
Dec. 22	Dec. 1	Product Showcase—Vol. II, Computers & Peripherals, Test & Measurement	

Call today for information:

East Coast: Janet O. Penn (201) 228-8610

West Coast: Dan Brink (714) 851-9422

National: Roberta Renard (201) 228-8602

# HARDWARE & SOFTWARE ENGINEERS

## You just found a place to develop your best ideas

Now you have the resources to develop your technical ingenuity into real-world capabilities. The place is NEC America's Radio & Transmission Group. And the challenge is ideal.

NEC America leads the field in T1 carrier transmission. We know what it takes to turn computer and communications technology into world-class digital links that meet any need. Short haul or long. Point to point or multipoint. Inter-city or global. Voice, data and video. And we'll continue to provide the best solutions through progressive development efforts underway now in the U.S.

Continuous innovation is our edge in the market; it's your ticket to the forefront of the industry. If you're ready to break new ground in hardware and software, NEC America is the place to put your ideas into action.

### **HARDWARE DEVELOPMENT Hillsboro, Oregon**

As the demands for specialized communications services skyrocket, the demands for economy and performance tighten. That's why NEC America invests significant effort into the design and development of powerful hardware and systems features that respond to changing times. Because of this commitment, opportunities in hardware development exist at all levels at our operations in Hillsboro near Portland, Oregon.

This 210-acre complex includes extensive manufacturing and research operations where the state of the art is evident in every facet of our work. Here are just two examples of the hardware challenges you'll find with us.

#### **Senior Hardware Development Engineers**

You will oversee the design of digital communications equipment as well as LSI circuitry via CAD systems. You'll also lead the test, analysis, and modification of prototype equipment and circuitry packages. Working with the customer and other NEC personnel as well as design and delivery schedules, cost analysis, new production training, and writing patent applications will also fall within your domain.

Thorough understanding of digital communications systems and engineering theories is essential at the senior level. You'll also need a BS in EE, Physics, or equivalent; at least five years experience designing digital communications equipment; and solid knowledge of CAD systems as well as C and Assembler programming.

#### **Hardware Development Engineers**

You'll apply your experience to the design and packaging of high-speed digital circuitry

that meet exacting cost and performance requirements. You'll be involved in all phases of development, from initial design through prototype test and modification all the way through to manufacturing and delivery.

To qualify, you must understand digital circuitry as well as other transmission and communications theory, CAD systems, and programming in C and Assembler languages. You should also have a BS in EE, Physics, or related field, and at least two years experience in the design of high-speed digital circuitry.

### **SOFTWARE DEVELOPMENT San Jose, California**

NEC America excels in providing turnkey communications solutions that have a healthy impact on a client's bottom line. We have the systems know-how to tailor our solutions to a broad variety of configurations, and maximize system usage under any conditions. To make the most of new opportunities, we're looking for professionals who know what it takes to program a system to meet the highest quality standards. Current openings exist for:

#### **Software Engineers**

You will develop network management features for performance monitoring, alarm surveillance, remote controls, trouble analysis, work force administration, and report/screen interfaces.

Your background must include 3-5 years experience which demonstrates knowledge of network management and transmission equipment as well as experience in a high-level development environment (UNIX, C). You must also be familiar with structured programming and development methodology. A BS/MS in CS or EE is preferred.

#### **Systems Programmers**

You will develop operating systems network interfaces including RS 232, X.25, ISDN, database management, command parsers, real-time performance, and recovery/back-up systems.

You'll need 3-5 years experience with operating systems; in-depth knowledge of UNIX and its support tools, structured programming, and development methodology; and familiarity with microprocessors. A BS/MS in CS or EE is preferred.

#### **Human Factors Engineer**

You will design human-machine interfaces including screens, forms, reports, and train-

ing materials; and evaluate customer operations and design demonstrations.

The ideal candidates will have experience with telecommunications operations and working knowledge of MMI, OSI, CASE, and SASE standards. An MS in Psychology and 3-5 years experience are preferred.

#### **System/Performance Engineer**

You will design performance models, generate traffic profiles, evaluate performance, design benchmark and load tests, and test and tune models and systems.

To qualify, you must have experience with performance modeling load testing and telecommunications networks, knowledge of queuing network analyzers, and strong oral and written communications skills. An MS in Statistics/Math with a BS in CS/EE is preferred.

#### **Quality Assurance Engineer**

These roles involve generating and executing systems test plans for supervisory systems, and evaluating software requirements and designs. You will also participate in design walkthroughs and reviews and determine minimum criteria for the release of software generics.

Demonstrated expertise in the design, development, and/or test of complex software is essential. You must also possess strong analytical skills with the ability to envision the whole system. Knowledge of facility maintenance systems along with a BS in EE or CS with 2-3 years experience are preferred.

### **Find out how far we can take you.**

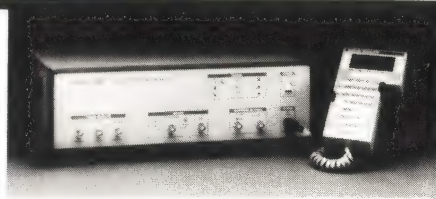
Few companies can match our progress with computers and communications technology. Look at existing NEC products and services for proof of our ability to provide fast, reliable, cost-efficient data and voice communications. Take another look at our drawing boards and you'll see that NEC America is ready for the next generation as well.

You will be too if you're ready for the development challenge at NEC America. Send your resume and salary history to our headquarters: NEC America, Inc., Radio & Transmission Systems Group, Attn: Personnel (EDN), 14040 Park Center Road, Herndon, VA 22071. We are an equal opportunity employer.

**C&C**  
Computers and Communications

**NEC**

# Innovators In Test And Measurement Instrumentation



LeCroy 9100 High Speed Arbitrary  
Function Generator

Being part of a small, innovative group is one of the most exciting and rewarding ways to spend your working life. And innovation is what LeCroy Corporation is all about. Over the last few years we have established ourself as the emerging company in T&M through the unique competence of our products and our people. Innovation has given us respect (6 IR awards in 5 years), exceptional growth and lots of fun along the way.

But there is so much more to be done! Can you help?  
Right now we have openings for:

## ANALOG/DIGITAL/SOFTWARE ENGINEERS

We're looking for candidates who can get excited about ultra high speed ADC's, signal conditioning, graphic displays, instrument control and signal processing that are the essence of tomorrow's digital oscilloscopes and arbitrary function generators. Our R&D groups are small, work closely with marketing and the customers, and have access to the most advanced tools with which to excel (most of our key designs are implemented in custom designed monolithic and hybrid circuits).

## MARKETING POSITIONS INCLUDE:

- **Marketing Manager (Modular Waveform Products)**
- **North American Sales Manager (Oscilloscopes)**
- **Applications Engineer (Function Generator)**
- **Technical Writer**
- **Field Sales Engineers (Territories throughout the USA)**

LeCroy, privately owned by the management team and employees, is located just 35 miles from New York City in a rural setting. Mountain trails, ski slopes and aquatic recreational areas are easily accessible along with superb educational and cultural resources.

We want the best people, and we've structured our compensation/benefits package to attract them. Please forward your resume and a letter of introduction to LeCroy Corporation, Dept. X, 700 Chestnut Ridge Road, Chestnut Ridge, NY 10977-6499. An equal opportunity employer, M/F

# LeCroy

*Innovators in Instrumentation*

## WE HAVE BUILT A REPUTATION...

Corporate Directions is a search & recruiting firm, building relationships, not just with our client-companies, but with our candidates as well.

Engineering professionals come to us because we can offer them individual choices; both professionally and geographically.

We have fee-paid openings, nationwide for degreed, experienced engineers in all disciplines.

Send resume in confidence to:

### CORPORATE DIRECTIONS

124 W. Orion #F-10  
Tempe, AZ 85283  
(602) 730-1677

We have built a reputation based on honesty, discretion, and professionalism.

Leading company in the building automation field has an opening for a Senior Design Engineer. We develop microprocessor based control systems for comfort control in commercial and industrial environments. Position requires a minimum of 5 years of design experience in the following areas: Multi-processor communications, micro-processor based hardware, analog circuit design A/D, D/A, interface, assembly language software design, some mechanical/packaging experience. Minimum of 2 years project management experience required. Applicants must have "hands on" experience in the above areas. Reply to:

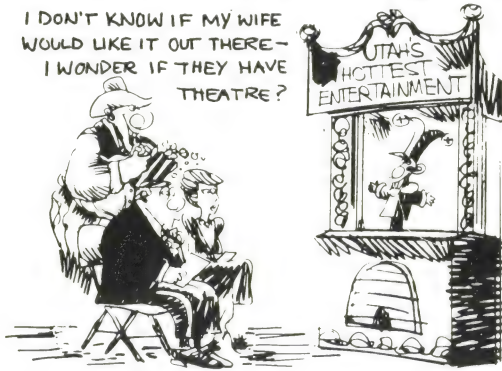
**Box 0180, EDN**  
**Cahners Publishing Company**  
**103 Eisenhower Parkway**  
**Roseland, NJ 07068**

# EDN

**First in Readership Among Design  
Engineers and Engineering  
Managers in Electronics**

# We can take a joke

I DON'T KNOW IF MY WIFE  
WOULD LIKE IT OUT THERE—  
I WONDER IF THEY HAVE  
THEATRE?



but seriously. . .

IOMEGA Corporation is a leader in mass storage technology, and the producer of the patented Bernoulli Box. We are in an aggressive growth mode, and have the new orders to make job offers worthwhile. And to make you see Utah in a whole new light.

Join us now as:

## Tribologist

You will investigate new head/desk and cartridge/desk interface concepts for advanced high performance flexible disk drives. Responsibilities include: Analytical modeling and empirical verification of design concepts.

Your background should include at least 4 years' in Tribology, with magnetic storage industry experience strongly preferred. BS in Mechanical Engineering or Physics, with graduate work preferred.

## Recording Physicist

In this position you will investigate new head/media/channel combinations which could increase the storage capacity of advanced high performance flexible disk drives and be responsible for analytical modeling and laboratory testing of new designs. To qualify, you should have a minimum of 4 years' experience in magnetic recording heads and/or media and/or read-write channels. You should have in-depth knowledge of the physical processes of magnetic recording. BS in Electrical Engineering or Physics, with graduate work preferred.

## Software Design Engineers

We have positions available for software designers with 2-5 years' software development experience in application, device driver or test system software development for MS-DOS, OS-2 and/or Apple Macintosh operating systems. Responsibilities include following a product from specification, through design, implementation, documentation and testing, and into production. Positions require BSEE, BSCS or equivalent degree or experience, and experience in developing software in a micro- or minicomputer system environment. C programming language and 8086/80286/80386 assembler experience are preferred. Successful candidates must also have good writing and communication skills and enjoy challenging software development work in a team environment.

## Mechanical Design Engineer

Work as a team member to develop new removable media disk drive products. Design close tolerance plastic and metal components and assemblies for state-of-the-art products. You will work with manufacturing to move the product into high volume production. Position requires a BS/MS degree in Mechanical Engineering. Experience in the design of disk drive mechanics desirable.

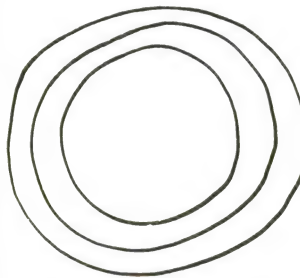
## Analog Design Engineer

You will be responsible for the design and evaluation of circuitry associated with advanced techniques in the magnetic digital recording, optimizing analog circuitry for use in state-of-the-art removable disk drive products. To qualify, you should possess a BSEE with a minimum of 4 years' experience designing analog circuits. Experience in the design of read channel and phase locked read clock circuits is preferred.

Enjoy the art of engineering and the art of living well with an industry leader in cartridge disk drives and computer peripherals.

We offer highly competitive salaries and an excellent benefits package. Your upward mobility is no laughing matter, so send your resume with salary history to: IOMEGA Corporation, EDN 1788, 1821 West 4000 South, Roy, Utah 84067. Equal opportunity employer.

# I·MEGA



## Help Develop One Of The Best Computers Under The Florida Sun

MODCOMP, an AEG company with corporate offices located in South Florida, supplies real-time computer systems, products and services to diverse worldwide markets. We are currently beginning a long-term **new generation computer product development project** and will be recruiting for the following positions:

### UNIX/Real-Time Operating Systems Programmers

### Compiler Programmers

### Diagnostic Programmers

### Hardware Engineers

Gate Array Designers  
Digital Logic Designers  
Sr. Architectural Designers

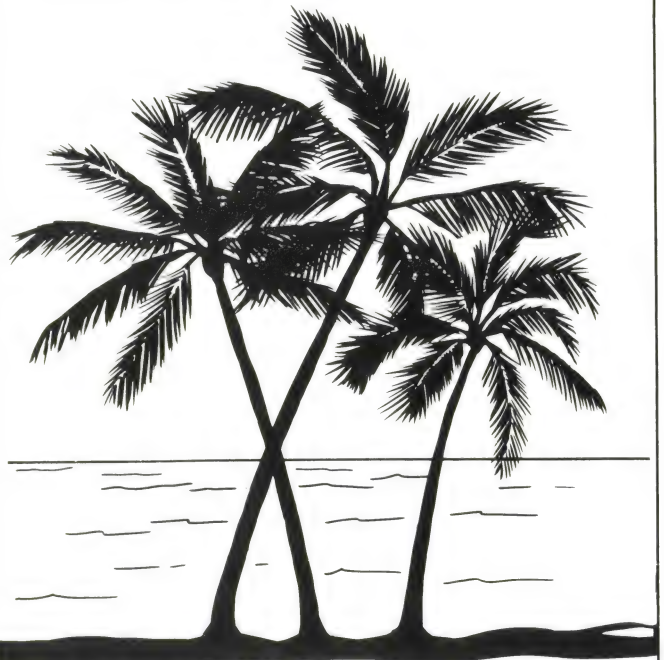
(All H/W positions require a BS Degree in Electrical Engineering).

### Communications Programmers

### Product Assurance Engineers

All positions are located at our corporate offices in Ft. Lauderdale, Florida.

MODCOMP offers an excellent benefits package and competitive salary in addition to an attractive 401(K) plan. We also offer a comprehensive relocation package. For consideration, send your resume in confidence to: Modular Computer Systems, Inc., Dept. JG 10, P.O. Box 6099, Ft. Lauderdale, FL 33340-6099. An Equal Opportunity Employer m/f.



# MODCOMP

an AEG company

# EDN Databank

## Professional Profile

### Announcing a new placement service for professional engineers!

To help you advance your career, Placement Services, Ltd. has formed the EDN Databank. What is the Databank? It is a computerized system of matching qualified candidates with positions that meet the applicant's professional needs and desires. What are the advantages of this new service?

- It's absolutely free. There are no fees or charges.

- The computer never forgets. When your type of job comes up, it remembers you're qualified.
- Service is nationwide. You'll be considered for openings across the U.S. by PSL and its affiliated offices.
- Your identity is protected. Your resume is carefully screened to be sure it will not be sent to your company or parent organization.

- Your background and career objectives will periodically be reviewed with you by a PSL professional placement person.

We hope you're happy in your current position. At the same time, chances are there is an ideal job you'd prefer if you knew about it.

That's why it makes sense for you to register with the EDN Databank. To do so, just mail the completed form below, along with a copy of your resume, to: Placement Services, Ltd., Inc.

#### IDENTITY

Name \_\_\_\_\_ Parent Company \_\_\_\_\_  
Home Address: \_\_\_\_\_ Your division or subsidiary: \_\_\_\_\_  
City \_\_\_\_\_ State: \_\_\_\_\_ Zip: \_\_\_\_\_ Location (City, State) \_\_\_\_\_  
Home Phone (include area code): \_\_\_\_\_ Business Phone if O.K. to use: \_\_\_\_\_

#### PRESENT OR MOST RECENT EMPLOYER

#### EDUCATION

Degrees (List)

Major Field	GPA	Year Degree Earned	College or University

#### POSITION DESIRED

#### EXPERIENCE

Present or Most Recent Position From: \_\_\_\_\_ To: \_\_\_\_\_ Title: \_\_\_\_\_

Duties and Accomplishments: \_\_\_\_\_ Industry of Current Employer: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Reason for Change: \_\_\_\_\_

#### PREVIOUS POSITION:

Job Title: \_\_\_\_\_  
Employer: \_\_\_\_\_ From: \_\_\_\_\_ To: \_\_\_\_\_ City: \_\_\_\_\_ State: \_\_\_\_\_  
Division: \_\_\_\_\_ Type of Industry: \_\_\_\_\_ Salary: \_\_\_\_\_  
Duties and Accomplishments: \_\_\_\_\_

#### COMPENSATION/PERSONAL INFORMATION

Years Experience	Base Salary	Commission	Bonus	Total Compensation	Asking Compensation	Min. Compensation
Date Available	I Will Travel <input type="checkbox"/> Light <input type="checkbox"/> Moderate <input type="checkbox"/> Heavy			<input type="checkbox"/> I own my home. How long? _____ <input type="checkbox"/> I rent my home/apt. <input type="checkbox"/>		
<input type="checkbox"/> Employed <input type="checkbox"/> Self-Employed <input type="checkbox"/> Unemployed		<input type="checkbox"/> Married <input type="checkbox"/> Single		Height _____ Weight _____		
Level of Security Clearance		<input type="checkbox"/> U.S. Citizen <input type="checkbox"/> Non-U.S. Citizen	My identity may be released to: <input type="checkbox"/> Any employer <input type="checkbox"/> All but present employer			
<input type="checkbox"/> WILL RELOCATE <input type="checkbox"/> WILL NOT RELOCATE <input type="checkbox"/> OTHER _____						

# EDN Databank

## A DIVISION OF PLACEMENT SERVICES LTD., INC.

265 S. Main Street, Akron, OH 44308 216/762-0279

• ENGINEERS

• PROGRAMMERS

• ANALYSTS

# MEET 35 EMPLOYERS

**NOW INTERVIEWING**  
**SALARIES \$30,000 to \$75,000**

New York

Los Angeles

Washington, D.C.

Orlando

Cleveland

San Jose

Chicago

Huntsville

Boston

Dallas

Atlanta

Orange County

Philadelphia

St. Louis

Cincinnati

Phoenix

Minneapolis

Denver

Aerospace Engineer  
Electrical Engineers  
Electronics Engineers  
Microprocessors  
Semi Conductors  
Communications  
Industrial Engineers  
Mechanical Engineers

Data Processing  
Software Design  
Programmers  
Systems Analysts  
Industrial Sales  
Plant Engineers  
Chemical Engineers  
Plastics Engineers

At an Opportunity Center, you have a unique opportunity to meet representatives of top firms in private interviewing sessions all in a single day or evening. When you apply, your resume, minus your name, is reviewed by representatives of Opportunity Center sponsoring firms. You are notified as to which firms would like to meet you. PRIVATE INTERVIEWS CONDUCTED IN COMPLETE CONFIDENCE.

## COMPANIES WHO HAVE ATTENDED:

Allied Bendix  
Analysts International

Arinc

Arvin Calspan

Ball Aerospace

Bell Corporation

Boeing

Combustion Science Corp.

E-Systems, Inc.

Fairchild Republic

FMC

General Dynamics

General Electric

Grumman

GTE Labs

Hamilton Standard

Harris Electronic

Hercules Defense Systems

IBM

Intergraph

ITT

Lear Siegler

Litton Industries

Lockheed

LTV

Magnavox

Martin Marietta

Motorola

Northrop Corp.

Raytheon

Rockwell International

SCM Corp.

Teledyne

Texas Instruments

TRW

United Technology

UNISYS

Westinghouse

Xerox Corporation



MAIL RESUME TODAY TO

# OPPORTUNITY CENTER

265 S. Main St. Akron, OH 44308

# ADVERTISERS INDEX

Abbott Transistor Labs Inc . . . . .	237	Genum Corp . . . . .	135	SGS Semiconductor Corp . . . . .	66-67
ABC-Taiwan Electronics Corp . . . . .	268	GE/RCA Solid State . . . . .	48-49, 246-247	Sierra Power Systems . . . . .	241
ACCEL Technologies Inc . . . . .	271	Greatlink Electronics Taiwan Ltd** . . . . .	187	Silicon Systems Inc . . . . .	254
ACDC Electronics . . . . .	144	Harris Microwave Semiconductor . . . . .	180	Single Board Solutions . . . . .	271
Aeroflex Laboratories Inc . . . . .	197	Harris/Scientific Calculations Inc . . . . .	153	Software Components Group . . . . .	133
Aerovox Mallory . . . . .	221	Heritage Systems Corp . . . . .	268	Spectrum Software . . . . .	41
Airpax Corp/Cambridge Div . . . . .	253	Hewlett-Packard Corp . . . . .	6, 69-74, 226-227	Sprague Electric Co . . . . .	54
American Automation . . . . .	136	Hilevel Technology Inc . . . . .	223	Standard Grigsby Inc . . . . .	64
Analog Design Tools Inc . . . . .	113	Hitachi America Ltd* . . . . .	100-101	Statek . . . . .	269, 271
Analogic Data Precision . . . . .	229	Honlex Industrial Co Ltd . . . . .	268	Syltel . . . . .	272
Applied Microsystems Corp . . . . .	18-19	Hughes AircraftCo/ Connecting Devices Div . . . . .	156	TDK Corp . . . . .	97
Archimedes Software . . . . .	131	Information Scan Technology Inc . . . . .	272	TEAC Corp** . . . . .	C2
AT&T Technologies . . . . .	15-17	Inmos Corp . . . . .	10-11	Tektronix Inc . . . . .	36-37, 91, 107-108, 162-163
Atron Div of TL Industries . . . . .	81	Integrated Circuits Inc . . . . .	267	Tektronix-CAE Systems . . . . .	63
Augat-Interconnection Systems . . . . .	201	Intel Corp . . . . .	142-143	Telegenix . . . . .	42
Autodesk Inc . . . . .	83	Intusoft . . . . .	272	Teradyne Inc . . . . .	28-29
Axelen Industrial Inc . . . . .	270	I/O Tech . . . . .	211-214	Test Probes Inc . . . . .	265
B&C Microsystems . . . . .	270, 272	ITT Cannon . . . . .	79	Todd Products Corp . . . . .	267
Beckman Industrial Corp . . . . .	88	ITT Pomona Electronics . . . . .	264	Torema USA . . . . .	35
Belden Electronic Wire & Cable . . . . .	C4	Janco Corp . . . . .	138	Toshiba Corp . . . . .	140-141, 231, 233
Bergquist Co . . . . .	220	John Fluke Manufacturing Co Inc* . . . . .	C2, 20, 187	TTE Inc . . . . .	269
BP Microsystems . . . . .	270	KEC Electronics Inc . . . . .	171	United Technologies Microelectronics Center . . . . .	179
Brooktree Corp . . . . .	208-209	Kepco Inc . . . . .	173-178	Universal Data Systems . . . . .	C3
Brown Kellog Inc . . . . .	271	Leader Instruments Corp . . . . .	102	Vesta Technology Inc . . . . .	270
Burndy Corp . . . . .	44-45	Linear Systems** . . . . .	88	Vishay Intertechnology Inc . . . . .	222
Burr-Brown Corp . . . . .	93, 199, 266	Linear Technology Corp . . . . .	190	Weidmuller Inc . . . . .	219
Buscon . . . . .	68	Logical Devices Inc . . . . .	267	WinSystems Inc . . . . .	270
Bytek Corp . . . . .	230	Loral Instrumentation . . . . .	129	Wintek Corp . . . . .	269, 272
Caddock Electronics Inc . . . . .	32-33	LTX Corp . . . . .	84-85	Wollongong Group . . . . .	82
Cahners Exposition Group . . . . .	283	3M Fluoronics . . . . .	203-206	Wyse Technology . . . . .	12
Canon USA Inc . . . . .	217	Macsyma/Symbolics . . . . .	14	Xicor Inc . . . . .	56
Capital Equipment Corp . . . . .	269	Marconi Instruments* . . . . .	260	Zericon . . . . .	272
Case Technology . . . . .	139	Marion Systems Corp . . . . .	267	Zilog Inc . . . . .	195
Chinon America Inc . . . . .	259	Maxtor . . . . .	46		
Ciprico Inc . . . . .	25	Measurement Systems Inc . . . . .	40		
Clearprint . . . . .	127	Micro Networks . . . . .	98-99		
Comair Rotron Inc . . . . .	40	MicroSim Corp . . . . .	263		
Creative Cad Concepts Inc . . . . .	267	Midwest Components . . . . .	50		
Cubit/Proteus Industries Inc . . . . .	164	Mini-Circuits Laboratories . . . . .	3, 4, 26-27, 193		
Cybernetic Micro Systems . . . . .	65	MK Hansen . . . . .	269, 272		
Cypress Semiconductor . . . . .	23	Molex Inc . . . . .	286		
Dakota Digital . . . . .	269	MWS Wire Industries . . . . .	239		
Dale Electronics Inc . . . . .	1	MX-Com Inc . . . . .	268		
Dash, Straus, and Goodhue . . . . .	2	NCI . . . . .	271		
Data Display Products . . . . .	235	NDK . . . . .	218		
Data I/O Corp/Futurenet Div . . . . .	8	NEC Corp . . . . .	242-243		
Datel . . . . .	151	NS Tech** . . . . .	187		
Deltron Inc . . . . .	220	Octagon Systems . . . . .	272		
Digital Electronics Corp . . . . .	225	Olation Inc . . . . .	270		
Digital Media Inc . . . . .	268	Omron Electronics Inc* . . . . .	95		
Diversified Technology . . . . .	64	Patton & Patton . . . . .	270		
Dotronix . . . . .	257	Philips Test & Measuring Instruments Inc** . . . . .	53		
Du Pont Electronics . . . . .	38-39	Precision Monolithics Inc . . . . .	189		
Dynatem Inc . . . . .	13	Qua Tech Inc . . . . .	268, 271		
EH Titchener & Co . . . . .	42	Qualidyne Systems Inc . . . . .	35		
Electrochem . . . . .	216	Raytheon . . . . .	59		
Emerald Computers . . . . .	86	RLM Research . . . . .	267		
Ferranti Semiconductors . . . . .	34	Rockwell International . . . . .	61		
Force Computers Inc . . . . .	30-31	Rogers Corp . . . . .	269, 270		
Forth Inc . . . . .	53	Seagate Technology . . . . .	111		
Frequency Devices . . . . .	105				
Fujitsu Components of America Inc* . . . . .	34				
Fujitsu Limited** . . . . .	20				
Galiso Inc . . . . .	269				
GE Plastics . . . . .	43				

## Recruitment Advertising

Corporate Directions . . . . .	278
I-Omega . . . . .	279
LeCroy . . . . .	278
Modcomp . . . . .	279
Opportunity Center . . . . .	281

\*Advertiser in US edition

\*\*Advertiser in International edition

This index is provided as an additional service. The publisher does not assume any liability for errors or omissions.

# High Performance DESIGN



February 23-25, 1988  
Anaheim Convention Center • Anaheim Hilton • Anaheim Marriott  
Anaheim, California

Attend NEPCON West and get on the high performance track to quality in electronics manufacturing.

If you are responsible for circuit and system design, NEPCON West is your best source for high performance technology and fast-track solutions to your manufacturing problems across the board.

across the board.

## The Exhibition— High Performance in Action

See, touch, and compare the latest materials, components, devices, equipment, technologies and techniques used to create electronic products. Observe live product demonstrations by over 1,200 companies and divisions.

## The Conference— Fast Tracks to Solutions

The NEPCON West Conference Program offers solutions to problems in electronics manufacturing across the board. Learn from the experts in sessions that cover timely issues such as:

- Superconductivity Materials and Technology
- The Need for Standards for the Purpose of Moving Toward Automation in Electronic Packaging and Production
- Recent Advances in Tape Automated Bonding
- New advances in Achieving SMT Reliability and Manufacturability
- Introduction to New Technology Marketing

## Register Now!

Keep pace with the products, the people, and the information you need to reach peak performance at NEPCON West. Pre-register and get free admission to the exhibition.

Phone: 312/299-9311



Cahners Exposition Group  
1350 East Touhy Avenue  
P.O. Box 5060  
Des Plaines, Illinois  
U.S. Telex: 246148 CEGCGO DSP  
International Telex: 82882 CEG CHGO

## NEPCON West '88 Advance Registration Form

**COMPLETE AND MAIL TO:** Nepcon West '88, P.O. Box 7100, North Suburban, IL 60199-7100

**MAILING DEADLINE:** February 1, 1988. After February 1, 1988, do not mail. For free admission to exhibits only, bring completed form to a badge typist at the NEPCON registration center. (No one under 18 will be admitted)

PLEASE PRINT IN BLACK INK

### 1. General Information (Please print clearly) ☐ Mr. ☐ Ms. ☐ Mrs. ☐ Dr.

First Name	M.I.	Last Name
Job Title		
Company		
Division		
Mailing Address		Dept. or Mail Stop
City	State	Zip
Country		
Telephone	Telex	C3

### 2. Job Category (Check only one)

- |                                                               |                                                 |
|---------------------------------------------------------------|-------------------------------------------------|
| <input type="checkbox"/> A Circuit/System Packaging           | <input type="checkbox"/> F Corporate Management |
| <input type="checkbox"/> B Circuit/System Design              | <input type="checkbox"/> G Sales                |
| <input type="checkbox"/> C Production/Manufacturing           | <input type="checkbox"/> H Research/Development |
| <input type="checkbox"/> D Quality Control, Test & Inspection | <input type="checkbox"/> I Other                |
| <input type="checkbox"/> E Purchasing                         |                                                 |

### 3. Business Category (Check only one)

- |                                                                            |                                                                     |
|----------------------------------------------------------------------------|---------------------------------------------------------------------|
| <input type="checkbox"/> A Computers, Peripheral Equipment                 | <input type="checkbox"/> H Electronic Components and Sub-Assemblies |
| <input type="checkbox"/> B Office or Business Machine                      | <input type="checkbox"/> I Consumer Elec. Products                  |
| <input type="checkbox"/> C Communications, Systems/Equipment               | <input type="checkbox"/> J Automotive Electronics or Appliances     |
| <input type="checkbox"/> D Industrial Electronic Control Systems/Equipment | <input type="checkbox"/> K Independent Research, Test, Design       |
| <input type="checkbox"/> E Medical Electronics                             | <input type="checkbox"/> L Contract Manufacturing                   |
| <input type="checkbox"/> F Aircraft, Missiles, Space, Military             | <input type="checkbox"/> M Other                                    |
| <input type="checkbox"/> G Test and Measurement Equipment, Inst.           |                                                                     |

### 4. Number of Employees in Your Company (Check only one)

- ☐ A 1-99    ☐ B 100-499    ☐ C 500-999    ☐ D 1000-2999    ☐ E 3000+

### 5. I'm interested in the following product categories. (Check all that apply)

- |                                                 |                                                |
|-------------------------------------------------|------------------------------------------------|
| <input type="checkbox"/> A PC Design            | <input type="checkbox"/> C Circuit Assembly    |
| <input type="checkbox"/> B PC Board Fabrication | <input type="checkbox"/> D Circuit Packaging   |
|                                                 | <input type="checkbox"/> E Inspection and Test |

- ☐ A Please register me for exhibits only. Free admission with this form. Save \$15.00.  
☐ B Please send more information and registration materials for the Conference Program.  
☐ C Please send hotel information.  
☐ D My company is interested in exhibiting at future events.

# YES, WE CAN KEEP AMERICA COMPETITIVE IN THE ELECTRONIC & COMPUTER MARKETS



Can American manufacturers of electronic products and computers stay competitive with overseas manufacturers? Can they compete in the worldwide market for these products, as well as in their own domestic market? Cahners magazines believes the answer is Yes. But only if labor costs are brought down...if manufacturing becomes more efficient...if quality and reliability are improved...and if products are designed to meet the changing needs of the marketplace.

In the months ahead Cahners magazines will concentrate on finding solutions to these problems, in a series of articles called *Keeping America Competitive*. The series will run October 1987 through March 1988. There will be over 50 major articles in this series which will comprise over 1,000 pages of text material. It is the most comprehensive coverage of a single topic ever undertaken by Cahners magazines. Cahners is committed to finding solutions to these problems because they affect every reader and advertiser in our computer and electronics magazines. Watch for the *Keeping America Competitive* series every month in these Cahners magazines:

Datamation  
EDN  
EDN News

Electronic Business  
Electronic Manufacturing News  
Electronic Packaging & Production  
Electronics Purchasing

Mini-Micro Systems  
Semiconductor International  
Test & Measurement World

*For more information contact, Frank J. Sibley, Group Vice President*

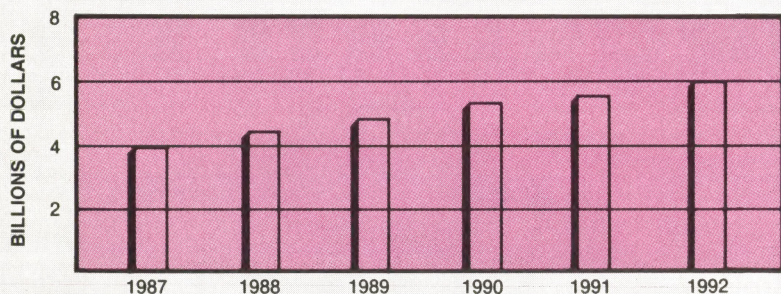
---

**Cahners Publishing Company** / A Division of Reed Publishing USA  
275 Washington Street • Newton, MA 02158 • 617/964-3030

# LOOKING AHEAD

EDITED BY CYNTHIA B RETTIG

## US PRODUCTION OF PRINTED-CIRCUIT BOARDS



(SOURCE: VENTURE DEVELOPMENT CORP)

### PC-board market to grow at 8% average rate per year

Because of the general electronics slump, open-market shipments of printed-circuit boards by US merchants have been declining since 1984. However, Venture Development Corp (VDC, Natick, MA) predicts a change for the better from now through 1992. The market-research firm suggests that this change may allow US merchants to recapture their former dominance of the US market. Assessed at \$4 billion in 1987, the US market for pc boards will grow at an annual average rate of 8% per year and reach \$6 billion by 1992. The US manufactures more than a third of the world's total supply of pc boards.

In comparison with the captive market, which VDC strictly defines as in-company sales (including division-to-division sales), the open market now commands a 52.6% market share. By 1992, the captive market's share should decrease to 41.7% as the open market's increases to 58.3%.

Although rigid circuit boards will retain their lead in terms of US board consumption, injection-molded pc boards will steadily increase their market share throughout the forecast period. The growth rate for injection-molded boards will exceed 50% annually. In consequence, these boards will start to eat into the market share of flexible pc boards.

In addition, multilayer pc boards will continue to replace double-sided boards in many applications. Multilayer pc boards are widely employed in data processing, communications, and aerospace/military/government applications. Use of the multilayer boards in such applica-

tions accounts for about 50% of US board consumption; by contrast, single-layer pc boards claim a small, and steadily decreasing, share of the US consumption of boards.

The use of surface-mount technology—which not only reduces a board's potential size but also increases its component density and improves its electrical performance—will increase during the forecast period. By 1992, more than half of all pc boards will employ at least some surface-mount components.

Currently, the data-processing and communications fields consume more than half of all US-manufactured pc boards. These two sectors are expected to increase their consumption at above-average growth rates through 1992.

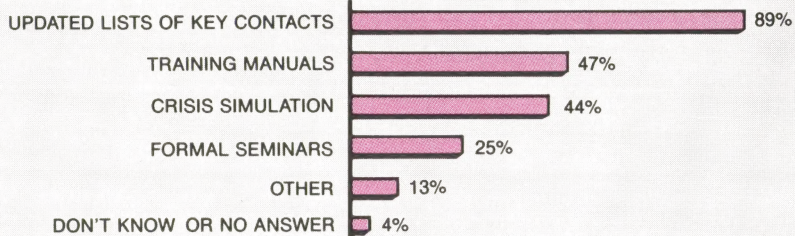
### More US companies plan for crisis communications

Fifty-seven percent of the largest corporations in the US now have operational plans for crisis communications, according to a survey commissioned by Western Union Corp (Upper Saddle River, NJ). The survey polled the top Fortune 1000 industrial and Fortune 500 service companies. Companies listed the following as important parts of crisis management: news releases, telephone contacts, press conferences, electronic mail, and up-to-date lists of key contacts. The situations in which such communications are nec-

essary include natural disasters, industrial accidents, mergers/takeovers, product recalls, and environmental problems.

The larger the company, the more likely it is to anticipate crises. Companies with over \$1 billion in revenues are considerably more likely to have crisis plans than are smaller companies. Although 75% of the larger companies have some plans and crisis teams in place, less than 50% of the smaller companies are prepared to face a crisis that would require extraordinary communications methods.

## ELEMENTS OF A CRISIS-COMMUNICATIONS PREPAREDNESS PROGRAM



(SOURCE: WESTERN UNION CORP)

*Making the Connection Between...*

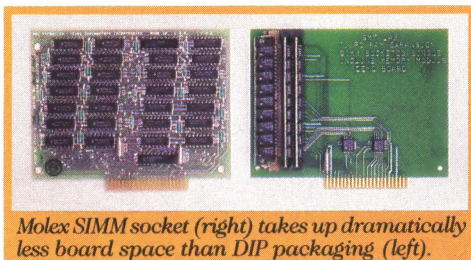
# PACKAGING & PRODUCTIVITY

**From through-hole technology to surface-mount technology, Molex makes the connection.**

Molex is working to help today's manufacturers develop SMT products that utilize less space and assemble with greater efficiency. Components such as our SIMM sockets are currently helping major manufacturers utilize innovative SIP technology to achieve denser circuit board packaging and increased RAM capacity. And, systems such as our automated robotic PCB assembly equipment are speeding production time and reducing labor costs.

**We take a systems approach to help make your bottom line more productive.**

Molex goes beyond quality SMT products to bring



*Molex SIMM socket (right) takes up dramatically less board space than DIP packaging (left).*

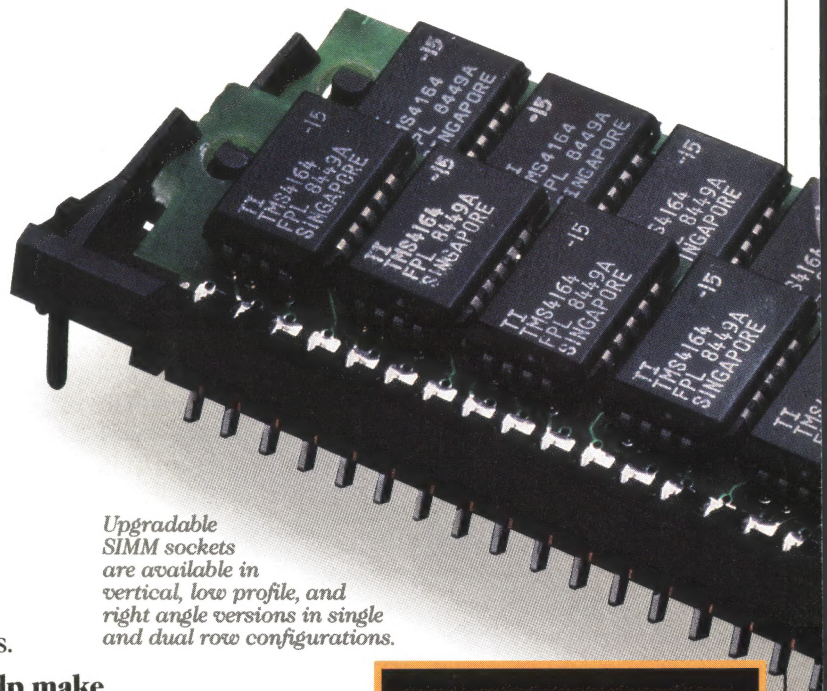
you problem-solving systems for greater productivity. Molex helps you put new technology to work in real world manufacturing situations. From design and development to

manufacturing and delivery, you can depend on Molex for interconnection technology that gives you a competitive edge.

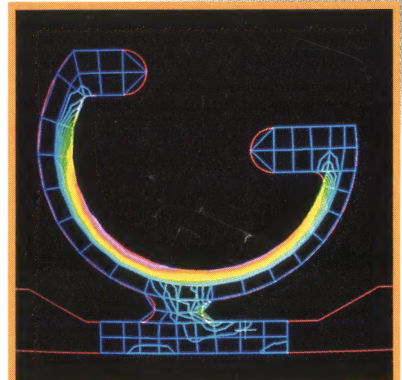
## **Connecting technologies worldwide.**

Our multi-national organization offers you interconnection design, manufacturing, and technology from around the globe, with dependable supply and local service.

Call or write today for our new 16-page SIMM Technology Handbook.



*Upgradable SIMM sockets are available in vertical, low profile, and right angle versions in single and dual row configurations.*



*As part of our intensive quality assurance efforts, CAD technology is used in product development to identify possible stress points.*

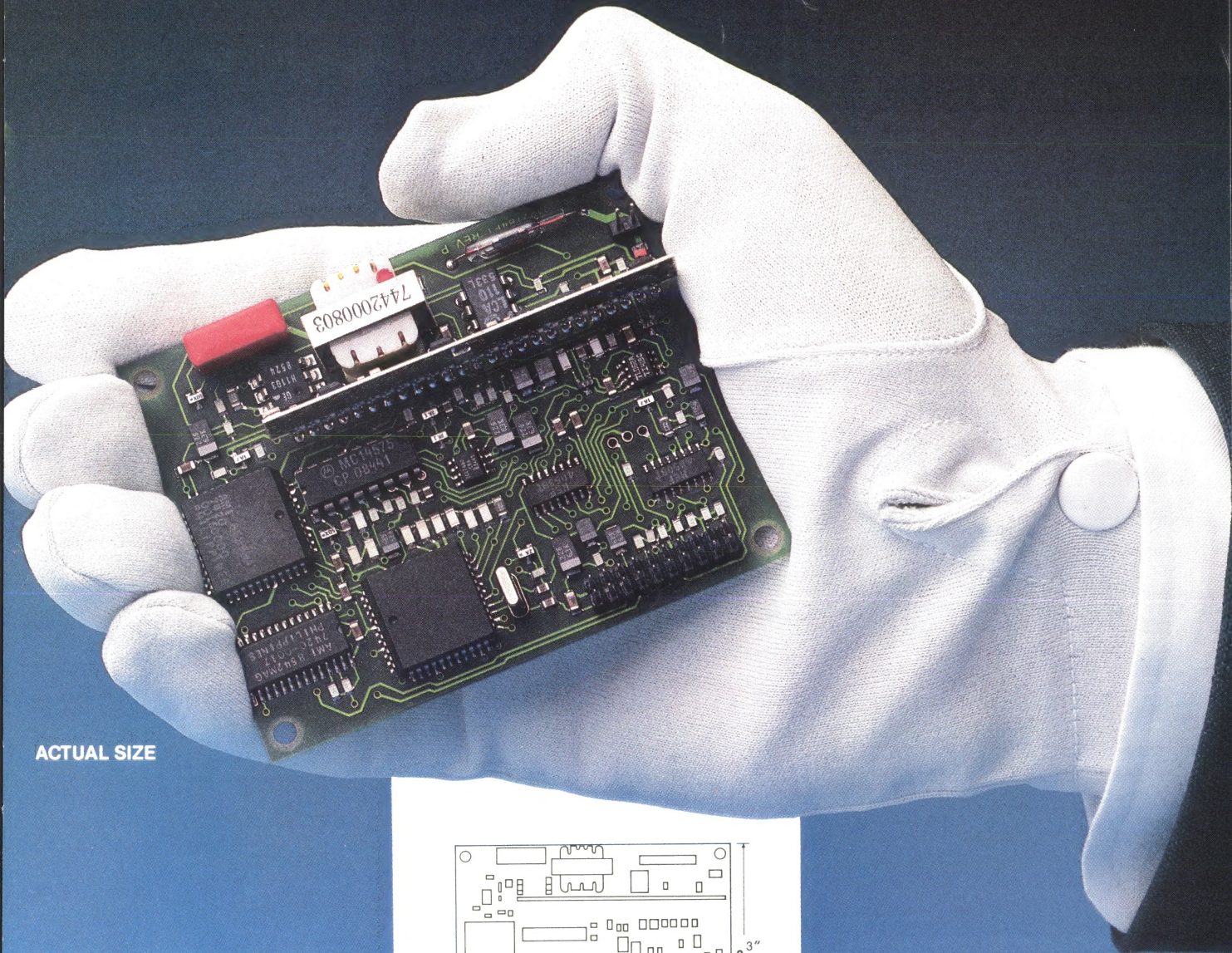
*Service To The  
Customer...Worldwide*



SIMM™ is a registered trademark of the Wang Corporation.

**Corporate Headquarters:** 2222 Wellington Ct., Lisle, IL 60532 USA, (312) 969-4550 • **European Headquarters:** Aldershot, England, (0252) 318221  
**Northern Asia Headquarters:** Tokyo, Japan, 03-478-8777 • **Southeast Asia Headquarters:** Jurong Town, Singapore, 65-261-9733

# MODEM DESIGN ELEGANCE AT 2400 BPS

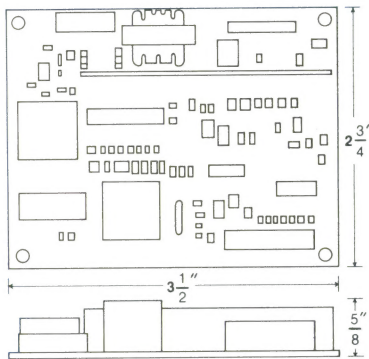


ACTUAL SIZE

## A FULLY FEATURED V.22 *bis* ON 9.6 SQ. IN.

At Universal Data Systems, surface-mount technology has brought a new level of engineering elegance to V.22 *bis* modem design. Using a combination of LSI and surface mounting techniques, we're now able to fit a *fully featured* V.22 or V.22 *bis* on 9.6 sq. in. of board space.

And when we say fully featured, we *mean* fully featured. Requiring +5 and  $\pm 12$ V to operate, this superminiature device has the same auto-dial, auto-answer, audio driver, line diagnostic and self-test features formerly found only on larger, heavier, more power-hungry and more expensive V.22s.



It's available now in a standard configuration, ready for internal mounting in the new terminal, microcomputer or other data communications device you're designing.

To be sure you're getting a true fully featured device at a most attractive price, contact UDS for

detailed specifications. Universal Data Systems,  
5000 Bradford Drive, Huntsville, AL 35805.  
Telephone 800/451-2369; Telex 752602 UDS HTV.



Universal Data Systems



**MOTOROLA INC.**  
Information Systems Group

CIRCLE NO 150

Created by Dayner/Hall, Inc., Winter Park, Florida

# BELDEN PROTECTS YOUR FIBER OPTIC SYSTEM THROUGH THE HARSHTEST ENVIRONMENTS

*Belden® Multipurpose  
Computer Fiber Optic Cable*

*Belden® General Purpose  
LAN Fiber Optic Cable*

Rain, snow, dust, heat—new applications continuously test the limits of fiber optic performance. Without cables engineered specifically for your application, you may not realize the durability and high-volume information transfer you expected from your fiber optic system.

Extensive experience in LAN, video, telecommunications, data communications, instrumentation, process control, government and military applications allows Belden to anticipate and conquer your worst-case operating environments.

In addition to a wide range of standard products, Belden can manufacture the single-mode, armored, hybrid and high-fiber-count cables you need. Breakout configurations are available for easy termination and fast installation. Belden fiber optic cables are available in single piece standard cut ups of 500, 1000, 3280 and 6560 feet. Custom lengths are also available.

Custom design, fast price and delivery information are as close as your local Belden Regional Sales office, while our nationwide distribution network can provide value-added services as well as cable selection and system design assistance.

When performance is critical—come heat or high water—contact Belden. We'll protect your fiber optic system through the harshest environments. Belden Wire and Cable, P.O. Box 1980, Richmond, Indiana 47375.

**1-800-BELDEN-4**

*Belden® Plenum Breakout  
Fiber Optic Cable*

*Belden® Heavy-Duty  
Direct Burial  
Fiber Optic Cable*

*Belden® BitLite® Military  
Fiber Optic Cable*

*Belden® Telecommunications  
Fiber Optic Cable*

**There is no equal.™**

Copyright © 1987 Cooper Industries, Inc.



**BELDEN**

CIRCLE NO 149